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# Apprenticeship and Industry Training

## Communication Technician

## Apprenticeship Course Outline

**2207 (2007)**

Alberta

Apprenticeship and Industry Training

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## Communication Technician
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### Course Outline


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## Apprenticeship

Apprenticeship is post-secondary education with a difference. Apprenticeship begins with finding an employer. Employers hire apprentices, pay their wages and provide on-the-job training and work experience. Approximately 80 per cent of an apprentice's time is spent on the job under the supervision of a certified journeyperson or qualified tradesperson. The other 20 per cent involves technical training provided at, or through, a post-secondary institution – usually a college or technical institute.

To become certified journeypersons, apprentices must learn theory and skills, and they must pass examinations. Requirements for certification—including the content and delivery of technical training—are developed and updated by the Alberta Apprenticeship and Industry Training Board on the recommendation of Communication Technician Provincial Apprenticeship Committee.

The graduate of the Communication Technician apprenticeship program is a certified journeyperson who will be able:

- supervise, train and coach apprentices
- use a thorough knowledge of electrical and electronic theory and its application to communication and associated equipment used in the telecommunication industry
- understand different circuit combinations and components
- competently use test instruments and understand their capabilities and limitations
- competently carry out mechanical functions required when completing repairs
- competently use test procedures to locate faults and isolate defective components
- set up and maintain local area networks, voice & data networks and wireless systems
- integrate emerging technology with existing technology and equipment
- read and interpret drawings, plans and specifications and layout and develop projects according to specifications
- co-ordinate communication work within the scope of the Communication Technician trade and other trades employed in the industry in both installation and maintenance settings
- perform assigned tasks in accordance with quality and production standards required by industry

## Apprenticeship and Industry Training System

### Industry-Driven

Alberta's apprenticeship and industry training system is an industry-driven system that ensures a highly skilled, internationally competitive workforce in more than 50 designated trades and occupations. This workforce supports the economic progress of Alberta and its competitive role in the global market. Industry (employers and employees) establishes training and certification standards and provides direction to the system through an industry committee network and the Alberta Apprenticeship and Industry Training Board. The Alberta government provides the legislative framework and administrative support for the apprenticeship and industry training system.

### Alberta Apprenticeship and Industry Training Board

The Alberta Apprenticeship and Industry Training Board provides a leadership role in developing Alberta's highly skilled and trained workforce. The board's primary responsibility is to establish the standards and requirements for training and certification in programs under the Apprenticeship and Industry Training Act. The board also provides advice to the Minister of Advanced Education and Technology on the needs of Alberta's labour market for skilled and trained workers, and the designation of trades and occupations.

The thirteen-member board consists of a chair, eight members representing trades and four members representing other industries. There are equal numbers of employer and employee representatives.

**Industry Committee Network**

Alberta's apprenticeship and industry training system relies on a network of industry committees, including local and provincial apprenticeship committees in the designated trades, and occupational committees in the designated occupations. The network also includes other committees such as provisional committees that are established before the designation of a new trade or occupation comes into effect. All trade committees are composed of equal numbers of employer and employee representatives. The industry committee network is the foundation of Alberta's apprenticeship and industry training system.

**Local Apprenticeship Committees (LAC)**

Wherever there is activity in a trade, the board can set up a local apprenticeship committee. The board appoints equal numbers of employee and employer representatives for terms of up to three years. The committee appoints a member as presiding officer. Local apprenticeship committees:

- monitor apprenticeship programs and the progress of apprentices in their trade, at the local level
- make recommendations to their trade's provincial apprenticeship committee (PAC) about apprenticeship and certification in their trade
- promote apprenticeship programs and training and the pursuit of careers in their trade
- make recommendations to the board about the appointment of members to their trade's PAC
- help settle certain kinds of disagreements between apprentices and their employers
- carry out functions assigned by their trade's PAC or the board

**Provincial Apprenticeship Committees (PAC)**

The board establishes a provincial apprenticeship committee for each trade. It appoints an equal number of employer and employee representatives, and, on the PAC's recommendation, a presiding officer - each for a maximum of two terms of up to three years. Most PACs have nine members but can have as many as twenty-one. Provincial apprenticeship committees:

- Make recommendations to the board about:
    - standards and requirements for training and certification in their trade
    - courses and examinations in their trade
    - apprenticeship and certification
    - designation of trades and occupations
    - regulations and orders under the Apprenticeship and Industry Training Act
- monitor the activities of local apprenticeship committees in their trade
- determine whether training of various kinds is equivalent to training provided in an apprenticeship program in their trade
- promote apprenticeship programs and training and the pursuit of careers in their trade
- consult with other committees under the Apprenticeship and Industry Training Act about apprenticeship programs, training and certification and facilitate cooperation between different trades and occupations
- consult with organizations, associations and people who have an interest in their trade and with employers and employees in their trade
- may participate in resolving certain disagreements between employers and employees
- carry out functions assigned by the board

**Communication Technician PAC Members at the Time of Publication**

| | | |
|---|---|---|
| Mr. D. Gibbon | Edmonton | Presiding Officer |
| Mr. K. Thiessen | Calgary | Employer |
| Mr. D. Smiley | Edmonton | Employer |
| Mr. L. Hovagimian | Ft. McMurray | Employer |
| Mr. T. Amos | Calgary | Employee |
| Mr. G. Darichuk | Calgary | Employee |
| Mr. K. Wilson | Calgary | Employee |

### Alberta Government

Alberta Advanced Education and Technology works with industry, employer and employee organizations and technical training providers to:

- facilitate industry's development and maintenance of training and certification standards
- provide registration and counselling services to apprentices and employers
- coordinate technical training in collaboration with training providers
- certify apprentices and others who meet industry standards

### Technical Institutes and Colleges

The technical institutes and colleges are key participants in Alberta's apprenticeship and industry training system. They work with the board, industry committees and Alberta Advanced Education and Technology to enhance access and responsiveness to industry needs through the delivery of the technical training component of apprenticeship programs. They develop lesson plans from the course outlines established by industry and provide technical training to apprentices.

## Apprenticeship Safety

Safe working procedures and conditions, incident/injury prevention, and the preservation of health are of primary importance in apprenticeship programs in Alberta. These responsibilities are shared and require the joint efforts of government, employers, employees, apprentices and the public. Therefore, it is imperative that all parties are aware of circumstances that may lead to injury or harm.

Safe learning experiences and healthy environments can be created by controlling the variables and behaviours that may contribute to or cause an incident or injury. By practicing a safe and healthy attitude, everyone can enjoy the benefit of an incident and injury free environment.

### Alberta Apprenticeship and Industry Training Board Safety Policy

The Alberta Apprenticeship and Industry Training Board fully supports safe learning and working environments and encourages the teaching of proper safety procedures both within trade specific training and in the workplace.

Trade specific safety training is an integral component of technical training, while ongoing or general non-trade specific safety training remains the responsibility of the employer and the employee as required under workplace health and safety legislation.

### Workplace Responsibilities

The employer is responsible for:

- training employees and apprentices in the safe use and operation of equipment
- providing and maintaining safety equipment, protective devices and clothing
- enforcing safe working procedures
- providing safeguards for machinery, equipment and tools
- observing all accident prevention regulations

The employee and apprentice are responsible for:

- working in accordance with the safety regulations pertaining to the job environment
- working in such a way as not to endanger themselves, fellow employees or apprentices

**Workplace Health and Safety**

A tradesperson is often exposed to more hazards than any other person in the work force and therefore should be familiar with and apply the Occupational Health and Safety Act, Regulations and Code when dealing with personal safety and the special safety rules that apply to all daily tasks.

Workplace Health and Safety (Alberta Employment, Immigration and Industry) conducts periodic inspections of workplaces to ensure that safety regulations for industry are being observed.

Additional information is available at www.worksafely.org

**Technical Training**

Apprenticeship technical training is delivered by the technical institutes and many colleges in the public post-secondary system throughout Alberta. The colleges and institutes are committed to delivering the technical training component of Alberta apprenticeship programs in a safe, efficient and effective manner. All training providers place great emphasis on safe technical practices that complement safe workplace practices and help to develop a skilled, safe workforce.

The following institutions deliver Communication Technician apprenticeship technical training:

- Northern Alberta Institute of Technology
- Southern Alberta Institute of Technology

**Procedures for Recommending Revisions to the Course Outline**

Advanced Education and Technology has prepared this course outline in partnership with the Communication Technician Provincial Apprenticeship Committee.

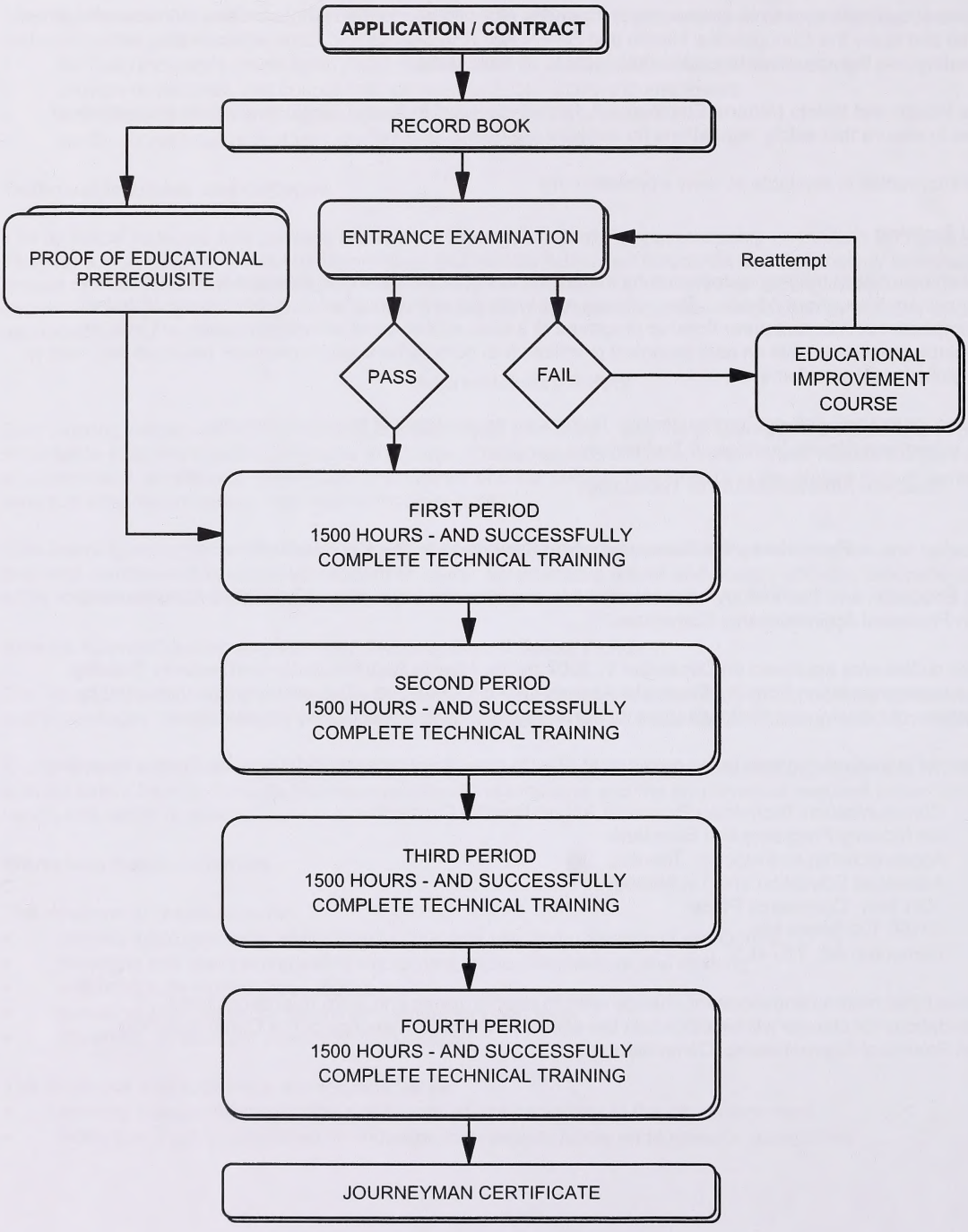
This course outline was approved on December 7, 2007 by the Alberta Apprenticeship and Industry Training Board on a recommendation from the Provincial Apprenticeship Committee. The valuable input provided by representatives of industry and the institutions that provide the technical training is acknowledged.

Any concerned individual or group in the province of Alberta may make recommendations for change by writing to:

Communication Technician Provincial Apprenticeship Committee
c/o Industry Programs and Standards
Apprenticeship and Industry Training
Advanced Education and Technology
10th floor, Commerce Place
10155 102 Street NW
Edmonton AB T5J 4L5

It is requested that recommendations for change refer to specific areas and state references used. Recommendations for change will be placed on the agenda for regular meetings of the Communication Technician Provincial Apprenticeship Committee.

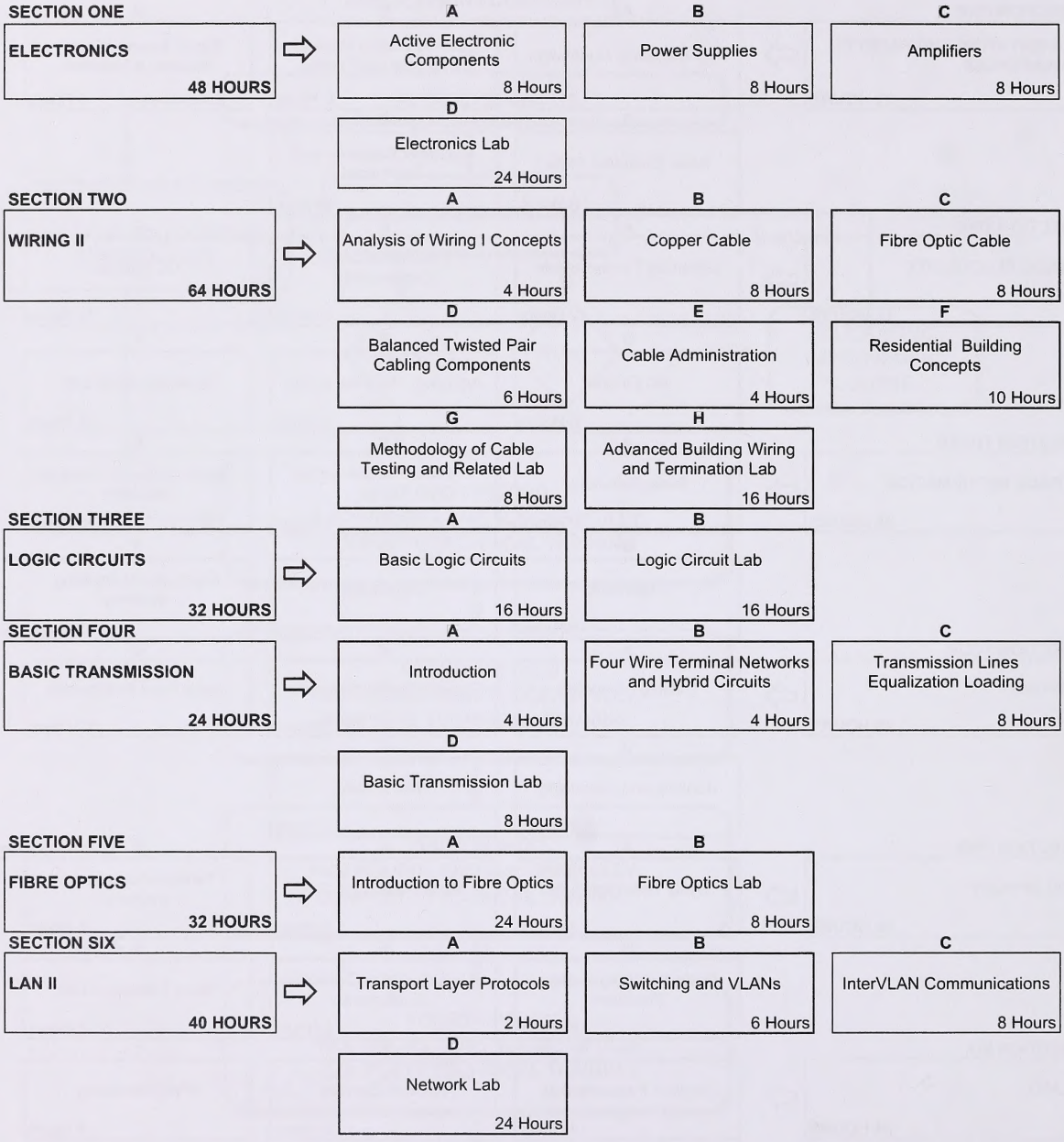
**Apprenticeship Route toward Certification**



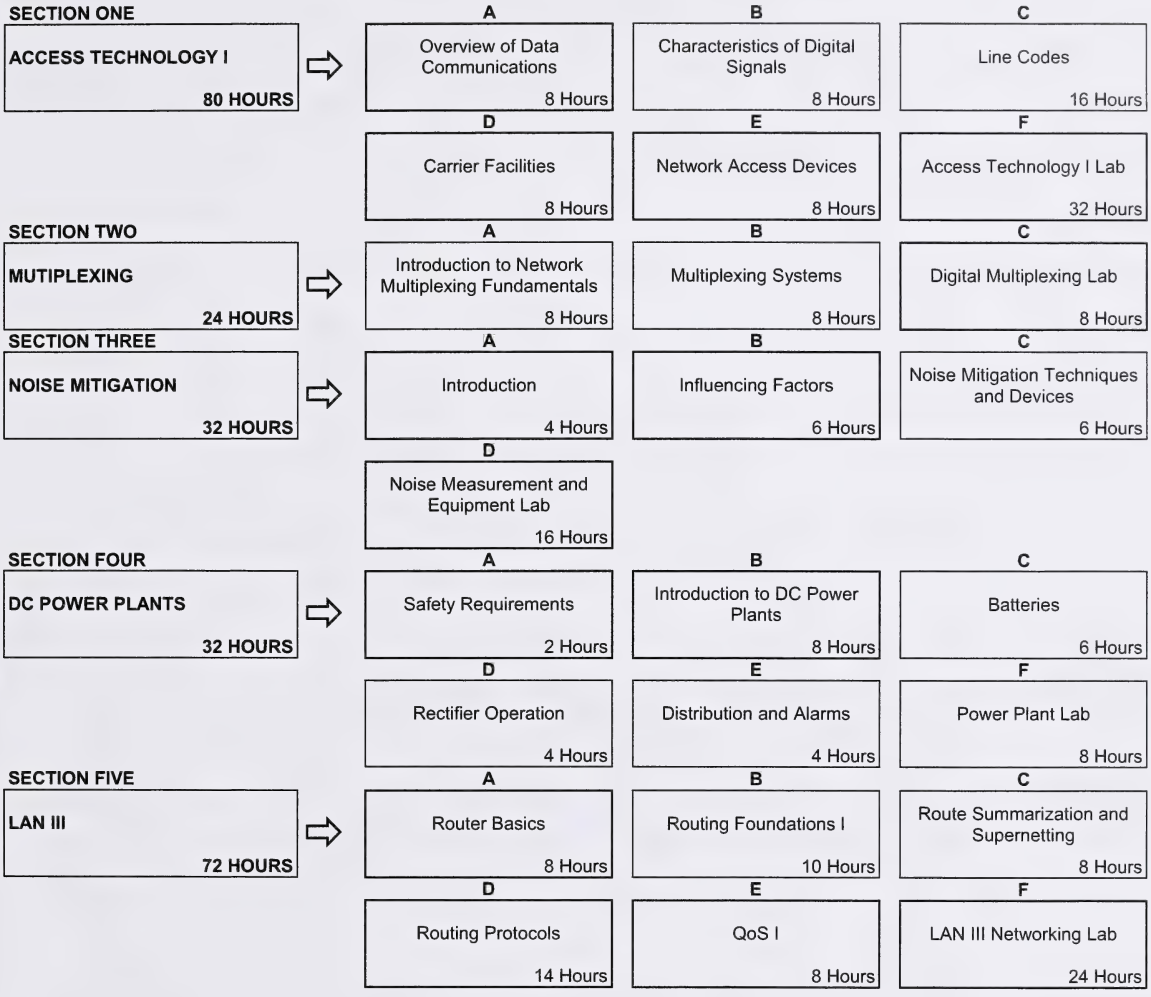
## Communication Technician Training Profile
## FIRST PERIOD
## (8 Weeks 30 Hours per Week – Total of 240 Hours)

| | | | |
|---|---|---|---|
| **SECTION ONE** | A | B | C |
| **ORIENTATION AND SAFETY AWARENESS** 32 HOURS | Apprenticeship Orientation 2 Hours | Communication Network Overview and Terms 6 Hours | Safety Awareness and Hazardous Materials 8 Hours |
| | D | E | |
| | Basic Computer Skills 8 Hours | Customer Relations and Teamwork 8 Hours | |
| **SECTION TWO** | A | B | C |
| **BASIC ELECTRICITY** 72 HOURS | Electricity Fundamentals 12 Hours | Passive Electrical Components 8 Hours | DC Circuits 16 Hours |
| | D | E | F |
| | AC Circuits 8 Hours | Analytical Troubleshooting 4 Hours | Basic Electricity Lab 24 Hours |
| **SECTION THREE** | A | B | C |
| **TRADE MATHEMATICS** 48 HOURS | Basic Arithmetic 10 Hours | Advanced Mathematical Topics 6 Hours | Trigonometry and Complex Numbers 16 Hours |
| | D | E | F |
| | Exponents 6 Hours | Logarithms 8 Hours | Alternative Numbering Systems 2 Hours |
| **SECTION FOUR** | A | B | C |
| **WIRING I** 40 HOURS | Cabling Standards 6 Hours | Outside Plant Architecture 10 Hours | Inside Plant Architecture 10 Hours |
| | D | E | |
| | Bonding and Grounding 2 Hours | Wiring Lab 12 Hours | |
| **SECTION FIVE** | A | B | C |
| **TELEPHONY** 24 HOURS | Basic Telephone Line 2 Hours | Basic Telephone Set 3 Hours | Telecommunications Systems 3 Hours |
| | D | E | F |
| | Basic Switching System Functions 6 Hours | Basic Customer Terminal Equipment 2 Hours | Basic Telephony Lab 8 Hours |
| **SECTION SIX** | A | B | C |
| **LAN I** 24 HOURS | Network Fundamentals 8 Hours | Network Devices 8 Hours | IPv4 Addressing 8 Hours |

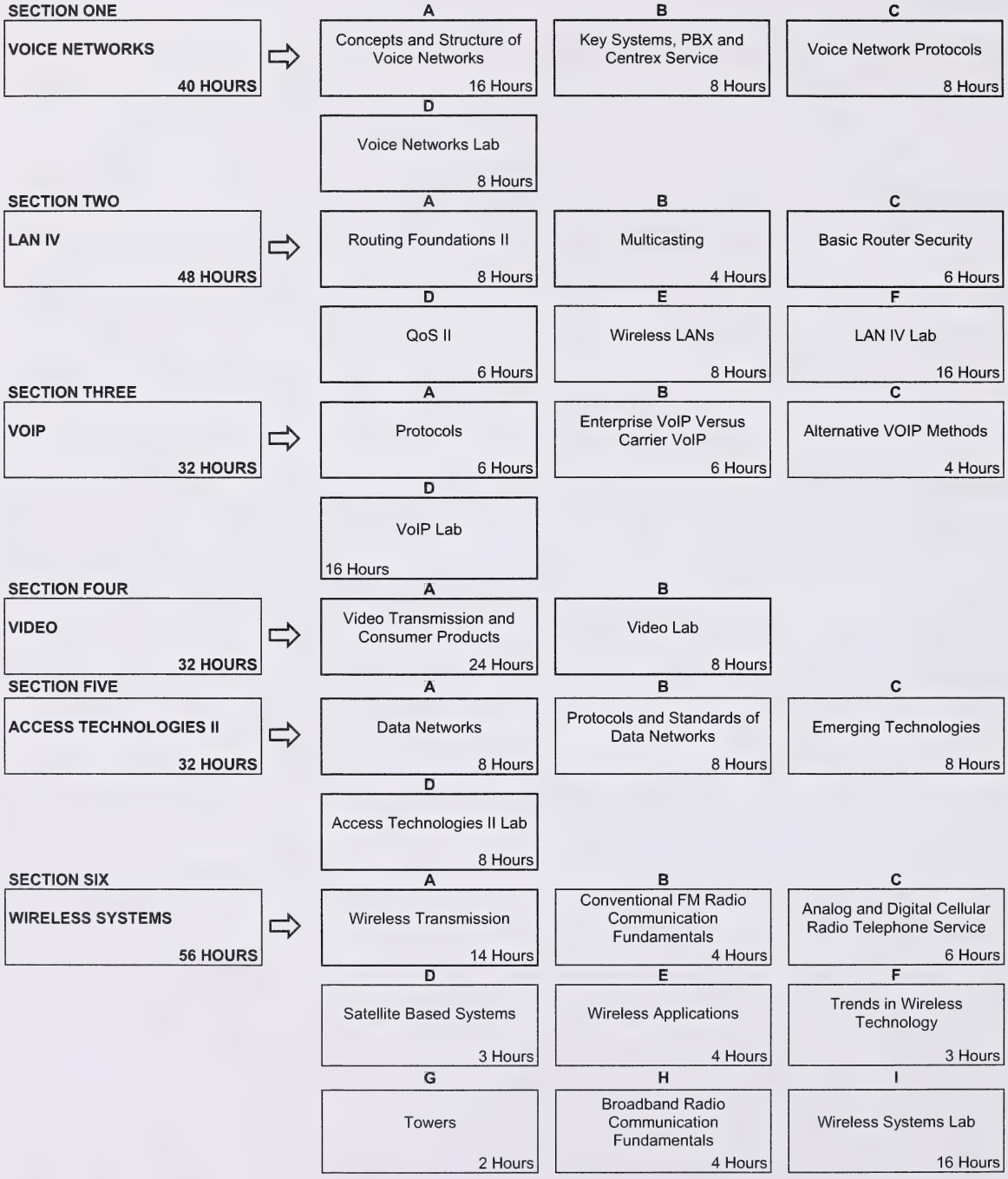
## SECOND PERIOD
## (8 Weeks 30 Hours per Week – Total of 240 Hours)



## THIRD PERIOD
## (8 Weeks 30 Hours per Week – Total of 240 Hours)



## FOURTH PERIOD
## (8 Weeks 30 Hours per Week – Total of 240 Hours)




NOTE: The hours stated are for guidance and should be adhered to as closely as possible. However, adjustments must be made for rate of apprentice learning, statutory holidays, registration and examinations for the training establishment and Apprenticeship and Industry Training.

**FIRST PERIOD TECHNICAL TRAINING**
**COMMUNICATION TECHNICIAN TRADE**
**COURSE OUTLINE**

*UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.*

**SECTION ONE: ..... ORIENTATION AND SAFETY AWARENESS ..... 32 HOURS**

**A. Apprenticeship Training Program Orientation .....2 Hours**

***Outcome:*** ***Describe the responsibilities and opportunities in the Communication Technician trade.***

1. Describe the apprenticeship training system in Alberta.
2. Identify the training profile of the Communication Technician Apprenticeship in Alberta.
3. Explain the Communication Technician course outline learning outcomes and objectives.
4. Describe the responsibilities for the Contract of Apprenticeship by the apprentice, employer and Alberta Apprenticeship and Industry Training.
5. Identify residential, commercial, industrial, and construction fields that provide employment opportunities for Communication Technicians.
6. Discuss the contents of the apprenticeship training Record Book.

**B. Communication Network Overview and Terms .....6 Hours**

***Outcome:*** ***Define the scope of the Communication Technician trade and be familiar with common terms associated with it.***

1. Outline the history of the telecommunication industry.
2. Describe the present telecommunication environment.
3. Identify emerging technologies, trends, and opportunities for future growth.
4. Describe various terms associated with the Communication Technician Trade, including but not limited to:
   - a) Co-Locate
     - i) POI
     - ii) POP
     - iii) POT
   - b) ILEC/CLEC Interconnect
   - c) Meet Me Room
   - d) TAIL CCTS
   - e) Competitive Digital Network Access (CDNA)
     - i) DS1
     - ii) DS3
   - f) GPS

**C. Safety Awareness and Hazardous Materials.....8 Hours**

***Outcome:*** ***Use appropriate safety procedures and equipment and work safely around hazardous materials.***

1. Describe employer and employee responsibilities regarding personal safety.
2. Describe the application of the following personal protective equipment:
   a) eye protection
   b) safety headgear
   c) respiratory protection
   d) clothing
   e) foot wear
   f) gloves
3. Describe the safe application of voltage testing equipment.
4. Describe the safe application of gas detection equipment.
5. Describe the care and safe use of ladders.
6. Describe the care and safe use of climbing gear.
7. Describe the Workplace Hazardous Materials Information System (WHIMS) Program.
8. Describe the function and purpose of the Transport of Dangerous Goods (TGD) Program.
9. Describe the handling procedures for hazardous goods.
10. Describe the characteristics of propane.
11. Describe safety precautions associated with storage, handling and use of propane.
12. Describe the maintenance of propane cylinders, gauges and hoses.
13. Explain the transportation procedures for propane.
14. Define confined space.
15. Identify types of confined space hazards:
    a) oxygen deficiency
    b) explosive gases
    c) toxic gases

**D. Basic Computer Skills.....8 Hours**

***Outcome:*** ***Execute basic functions on computer work stations.***

1. Describe the basic operating systems of microcomputers.
2. Navigate between all applications in Microsoft Office Suite.
3. Produce and save basic documents using word processing and spreadsheet applications.

**E. Customer Relations and Teamwork.....8 Hours**

***Outcome:*** ***Develop satisfactory working relationships with customers and work associates.***

1. Describe the basic protocol when dealing with customers.
2. Use acceptable oral and written communication skills around customers and work associates.
3. Describe the basic organizational structure and working relationships of successful teams.

**SECTION TWO: ..... BASIC ELECTRICITY ..... 72 HOURS**

**A. Electricity Fundamentals ..... 12 Hours**

***Outcome:*** ***Describe the basic fundamentals of electricity including Ohm's law, analytical troubleshooting, conductors, analog & digital meters and magnetism.***

1. Describe practical applications of the general principles of electricity.
2. Describe the components of basic circuits.
3. Describe the structure of the atom.
4. Define, give symbols, and state units of measurement for the following electrical terms:
   a) coulomb as a unit of charge
   b) volt as a unit of potential difference
   c) amp as a unit of current
   d) ohm as a unit of resistance
5. Describe the term closed circuit.
6. Describe the term open circuit.
7. Describe the term short circuit.
8. Describe the term conductance.
9. Explain direction of current:
   a) electron flow
   b) conventional flow
10. Identify sources of electricity.
11. Describe the difference between alternating current and direct current.
12. Describe the direct relationship between V & I.
13. Describe the inverse relationship between I & R.
14. State the forms of Ohm's Law.
15. Perform calculations using all forms of Ohm's Law.
16. Perform calculations using multiple and sub-multiple units for:
    a) current
    b) voltage
    c) resistance
17. Explain power dissipation and work in a resistance.
18. Calculate power dissipation in a resistance.
19. Explain the relationship between voltage, current, resistance and power.
20. State forms and perform calculations using power formulas.
21. Identify and describe the following types of analog and digital DC meters:
    a) moving coil meters
    b) voltmeters
    c) ohmmeters
    d) multimeters
    e) ammeters
22. Describe common applications for analog and digital DC meters.
23. Explain conductors.

24. Identify the magnetic polarity of a coil.
25. Explain the effect of wire resistance in a circuit.
26. Explain the purpose of insulators.
27. Identify and describe the types of insulators.
28. Define the following magnetic terms:
    a) magnetic field
    b) magnetic flux
    c) flux density
    d) induction by magnetic fields
    e) reluctance
    f) Ampere/turns
    g) field intensity
    h) Ohm's Law of magnetic circuits
    i) hysteresis
29. Explain the effects of an air gap on a magnet.
30. Identify the types of magnets:
    a) permanent
    b) electromagnet
31. Define permeability.
32. Explain magnetic shielding.

**B. Passive Electrical Components.....8 Hours**

***Outcome:*** ***Explain the operation of the following passive electrical components including resistors, inductors, relays, capacitors and transformers.***

1. Explain resistors.
2. Explain the induction of current.
3. State Lenz's Law.
4. Explain the generation of induced voltage.
5. Describe typical electrical circuit components:
    a) switches
    b) fuses
    c) indicators
6. Identify and describe relay components.
7. Explain relay contact operation.
8. Explain relay windings:
    a) same direction
    b) differential
    c) non-inductive
9. Describe the operation of relays.

**C. DC Circuits.....16 Hours**

***Outcome:*** ***Explain the operation of DC circuits and battery components.***

1. Define, calculate and analyze series DC circuits.
2. Define, calculate and analyze parallel DC circuits.
3. Troubleshoot the effects of opens and shorts on a parallel circuit.
4. Define, calculate and analyze series/parallel DC circuits.
5. Analyze the effects of opens and shorts on series/parallel circuits.
6. Describe types of grounding.
7. Describe DC power sources.
8. Explain internal resistance of generators.

**D. AC Circuits.....8 Hours**

***Outcome:*** ***Describe AC current and voltage, AC power sources, inductive circuits, capacitive circuits, RLC in AC circuits and resonance.***

1. Explain alternating current theory.
2. Identify sources of sinusoidal AC wave forms:
   a) motors and generators
   b) 60 Hz AC power line
3. Describe series and parallel resistive AC circuits.
4. Describe series and parallel inductive AC circuits.
5. Describe XL in terms of an AC resistance (impedance) called inductive reactance.
6. Calculate XL, L and frequency given any two of the variables.
7. Add inductive reactances in series and parallel.
8. Perform Ohm's Law calculations with XL.
9. Identify applications of inductive reactance.
10. Calculate the effect of inductive reactances and resistances in series and parallel circuits.
11. Explain the term "back EMF".
12. Calculate L/R time constant.
13. Describe the hazards associated with the high voltage produced by opening RL circuits.
14. Perform a comparison of time constant and reactance.
15. Describe series and parallel AC capacitive circuits.
16. Explain how charge is stored in a dielectric.
17. Explain the charging and discharging of capacitors.
18. Describe typical capacitors:
    a) electrolytic
    b) bipolar
19. Calculate capacitor value using:
    a) colour code
    b) number system
20. Explain how AC voltage produces AC current in a capacitive circuit.

21. Explain the current and voltage phase relationship in series and parallel circuits.
22. Calculate and explain the relationship between capacitances in series and parallel.
23. Describe the effects of stray inductance and capacitance.
24. Identify and troubleshoot common problems with capacitors.
25. Describe XC in terms of an AC resistance (impedance) called capacitive reactance.
26. Describe alternating current in a capacitive circuit.
27. Calculate XC, C and frequency given any two of the variables.
28. Add capacitive reactances in series and parallel.
29. Perform Ohm's Law calculations with XC.
30. Identify applications of capacitive reactance:
    a) voltage dividers
    b) coupling capacitors
31. Explain sinewave charge and discharge current.
32. Calculate and explain the effect of capacitive reactances and resistances in series and parallel circuits.
33. Describe series and parallel RL circuits.
34. Describe series and parallel RC circuits.
35. Describe series and parallel RLC circuits.
36. Calculate and explain RC time constant and wave shapes.
37. Describe long and short time constants.
38. Describe the universal time constant graph.
39. Compare time constant and reactance.
40. Describe RC phase shifter circuit.
41. Perform Ohm's Law calculations with the following:
    a) AC resistive circuits
    b) AC inductive circuits
    c) AC capacitive circuits
    d) AC circuits with opposing reactances
    e) AC circuits with reactance and resistance in series and parallel circuits
42. Perform power calculations:
    a) real
    b) reactive
    c) apparent
43. Describe phase relationships in LR, CR, and LRC series and parallel circuits.
44. Calculate phasors in AC circuits.
45. Explain AC maximum power transfer.
46. Describe the resonance effect.
47. Describe resonance in a:
    a) series circuit
    b) parallel circuit
48. Calculate the resonant frequency.

49. Calculate the Q magnification factor.
50. Describe the bandwidth of a resonant circuit.
51. Calculate the bandwidth of a resonant circuit.
52. Describe tuning.
53. Describe mistuning.
54. Analyze series and parallel resonant circuits.
55. Explain damping of parallel resonant circuits.
56. Choose inductance and capacitance for resonant circuits.
57. Explain transformer theory.

**E. Analytical Trouble Shooting .....4 Hours**

***Outcome:*** ***Employ analytical troubleshooting techniques.***

1. Define analytical troubleshooting.
2. Describe analytical problem solving techniques.
3. Identify causes against known standards or specifications.
4. Explain how multi-problem resolutions are accomplished through analytical troubleshooting techniques:
   a) isolating
   b) prioritizing
   c) resolving

**F. Basic Electricity Lab .....24 Hours**

***Outcome:*** ***Execute various basic electricity lab exercises including work with meters, circuits, voltage dividers, transformers, cells, power supplies, oscilloscope, inductors, and capacitors.***

1. Describe laboratory rules and procedures.
2. Correctly operate meters.
3. Test, measure and verify basic circuits.
4. Verify characteristics of loaded and unloaded voltage dividers.
5. Test transformers for input/output current and voltage characteristics.
6. Test cells and power supplies.
7. Measure and verify specified current characteristics using an oscilloscope.
8. Conduct specified lab exercises involving inductors.
9. Conduct specified lab exercises involving capacitors.

**SECTION THREE: .....TRADE MATHEMATICS.....48 HOURS**

**A. Basic Arithmetic.....10 Hours**

***Outcome:*** ***Perform basic arithmetic functions including fractions, algebra, percentage, factoring, ratio & proportion and units manipulation.***

1. Perform calculations with common and decimal fractions.
2. Perform the following mathematical calculations with the aid of a scientific calculator:
   a) addition, subtraction, multiplication and division of algebraic terms
   b) manipulation of positive and negative powers
   c) manipulation of roots and radicals
   d) solve algebraic equations with one unknown
   e) electrical application problems
3. Solve practical percentage problems.
4. Factor whole numbers and fractions.
5. Solve practical ratio and proportion problems.
6. Manipulate different MKS units with application in Engineering.

**B. Advanced Mathematical Topics .....6 Hours**

***Outcome:*** ***Perform formula manipulation, solve the system of two equations and solve series/parallel circuit problems.***

1. Perform formula manipulation as applied to basic AC/DC problems.
2. Solve the system of two equations using methods of substitution and elimination.
3. Solve series/parallel circuit problems.

**C. Trigonometry and Complex Numbers .....16 Hours**

***Outcome:*** ***Perform trigonometric functions including vectors, vector notation for AC circuits and manipulate complex numbers using the j Notation and algebra of complex numbers.***

1. Understand basic trigonometric ratios and their inverses.
2. Solve the right triangle.
3. Solve for angles in a different system of units.
4. Draw vectors in Cartesian and polar coordinates:
   a) vector algebra
   b) phase angles in radians
   c) phasor notation
   d) examples of impedance calculations using phasors
   e) mathematical representation of AC signal
5. Define j notation.
6. Explain the mathematical rules relating to j notation.
7. Define the complex number.
8. Explain rectangular and polar formats for complex numbers.
9. Determine the conjugate of a complex number.

10. Perform addition, subtraction, multiplication and division of complex numbers.
11. Describe the application of complex numbers in AC circuits.

**D. Exponents.....6 Hours**

***Outcome:*** ***Define and manipulate mathematical functions involving exponents.***

1. Define and explain the meaning of a zero exponent.
2. Define and explain the meaning of a negative exponent.
3. Define and explain the meaning of a fractional exponent.

**E. Logarithms.....8 Hours**

***Outcome:*** ***Define and manipulate logarithmic equations including decibels.***

1. Define logarithms.
2. Use logarithmic notation.
3. Explain the rules of logarithms.
4. Use common logarithms.
5. Solve logarithmic equations.
6. Define decibels.
7. Describe the application of decibels.
8. Define dBm, dBrn, and applications.
9. Define the natural logarithm and its inverse.
10. Describe properties of natural logarithms and the exponential function.
11. Describe the application of natural logarithms and the exponential function in LC and RC problems and general decay problems.

**F. Alternative Numbering Systems .....2 Hours**

***Outcome:*** ***Define and manipulate alternative numbering systems.***

1. Describe binary numbering systems.
2. Describe hexadecimal numbering systems.

**SECTION FOUR: ..... WIRING I ..... 40 HOURS**

**A. Cabling Standards .....6 Hours**

***Outcome:*** ***Recognize and use the correct cable standards and types of cables for given installations.***

1. Discuss the reasons for cabling standards.
2. Discuss the various cabling standards:
   - a) International Organization for Standardization (ISO)
   - b) ISO 11801 (Generic Cabling for Customer Premises)
   - c) American National Standards Institute (ANSI)
   - d) Institute Electrical Electronic Engineers (IEEE)
     - i) IEEE 802.3 (Ethernet)
   - e) Electronic Industries Alliance (EIA)
   - f) Telecommunications Industries Association (TIA)
     - i) ANSI/TIA/EIA-568-B.1 (Commercial Building Telecommunications Cabling), Standard Part 1: General Requirements
     - ii) ANSI/TIA/EIA-568-B.2 and B.2-ad10 (Commercial Building Telecommunications Cabling), Standard Part 2: Balanced Twisted Pair Cabling Components
     - iii) ANSI/TIA/EIA-568-B.3, Standard Part 3: Optical Fibre Cabling Component Standard
     - iv) ANSI/TIA/EIA-569-A, (Commercial Building Standard for Telecommunications Pathways and Spaces)
     - v) ANSI/TIA/EIA-570-B (Residential and Light Commercial Telecommunications Wiring Standard)
     - vi) ANSI/TIA/EIA-606 (Administration Standard for the Telecommunications Infrastructure of Commercial Buildings)
     - vii) ANSI/TIA/EIA-607 (Commercial Building Grounding and Bonding Requirements for Telecommunications)
     - viii) ANSI/TIA/EIA-758 (Customer-owned Outside Plant Telecommunications Standard)
   - g) Canadian Standards Association (CSA)
     - i) Current CSA equivalent documents for above
   - h) Canadian Electrical Code (CEC) Sections (Currently C22.1-06)
     - i) Section 10 (Grounding and Bonding)
     - ii) Section 16 (Class 1 and Class 2 circuits)
     - iii) Section 56 (Optical Fibre Cables)
     - iv) Section 60 (Electrical Communication Systems)

**B. Outside Plant (OSP) Architecture .....10 Hours**

***Outcome:*** ***Identify the equipment components and structures of outside plant architecture.***

1. Describe the Serving Area Concept (SAC).
2. Describe underground, direct buried and aerial components for the following:
   - a) OSP Infrastructure
   - b) OSP Cable Structure and Cable Types
   - c) OSP Cable Enclosures
   - d) OSP Color Codes
   - e) OSP Splicing Techniques

**C. Inside Plant Architecture.....10 Hours**

***Outcome:*** ***Identify the equipment components and structures of inside plant architecture.***

1. Describe Structured Cabling Systems (SCS) including:
   a) SCS Infrastructure
   b) Patch panels (PP)
   c) Cross-connects (X-Conn)
   d) Telecommunication Outlets (TOs)
   e) Multi-User Telecommunication Outlets (MUTOs)
   f) SCS Cable Structure and Cable Types
   g) SCS Color Codes
   h) SCS Termination Techniques
2. Describe the relationship of networking systems and topologies:
   a) architectures
   b) topologies
3. Describe building entrances and demarcation points:
   a) central office
   b) Main Distribution Frame (MDF)
   c) Intermediate Distribution Frame (IDF)
   d) Fibre Main Distribution Frame (FMDF)
   e) tie cables
   f) co-locate rooms
   g) customer premises
4. Identify and describe NID component parts.
5. Describe the function of NID component parts.
6. Describe the correct wiring configuration for NID protectors.
7. Describe protective devices.
8. Identify the appropriate protection devices to protect life and property of subscribers.
9. Describe telecommunication rooms (TR).
10. Describe vertical risers/backbone:
    a) pathways and spaces
    b) cable types
       i) usage specifications
       ii) fire ratings

**D. Bonding and Grounding.....2 Hours**

***Outcome:*** ***Use correct bonding and grounding equipment and procedures for a given installation.***

1. Explain the purpose of bonding and grounding:
   a) effects of lightning on communication systems
   b) effects of precipitation static on communication systems
2. Identify electrical safety regulatory bodies governing bonding and grounding of communication facilities:
   a) safety requirements for the last utility in
   b) procedures to be followed when foreign voltages have been located
   c) standard maximum measured voltage allowed before stopping work
3. Describe bonding and grounding requirements for central office equipment:
   a) remote sites
   b) Fibre Optic Transport System (FOTS) equipment
   c) central office locations
   d) cellular sites
   e) subscriber carrier
4. Describe latest developments in anti-static protection:
   a) anti-static flooring systems
   b) ground connections and maintenance
   c) anti-static mats and wrist straps
   d) static dissipative footwear

**E. Wiring Lab.....12 Hours**

***Outcome:*** ***Identify and use the correct tools to perform acceptable cable splicing and bonding & grounding procedures.***

1. Perform terminations on various blocks and panels:
   a) OSP cable testing methodology and required tools
   b) SCS cable testing methodology and required tools
   c) basic OSP cable splicing techniques
   d) basic SCS cable splicing and termination techniques
   e) basic bonding and grounding techniques

**SECTION FIVE:..... TELEPHONY .....24 HOURS**

**A. Basic Telephone Line .....2 Hours**

***Outcome:*** ***Draw and interpret simple and complex telephone circuits and describe cable characteristics.***

1. Draw and explain a simple telephone circuit (telephone to central office).
2. Draw and explain a complex telephone circuit (loop improvement equipment –loop extenders, VFR's, loading schemes).
3. Describe cable characteristics.

**B. Basic Telephone Set** ..... **3 Hours**

***Outcome:*** ***Explain the operation of the basic telephone set and analyze the circuits of various types of telephone sets.***

1. Identify components of a typical telephone set.
2. Explain the theory of operation of the following:
   a) transmitter
   b) receiver
   c) touch-tone pad
   d) hook switch
   e) ringer and capacitor
   f) network (sidetone)
3. Describe the characteristics of:
   a) 2500 set
   b) electronic set
   c) digital set
   d) cordless phones
   e) IP phones

**C. Telecommunication Systems** ..... **3 Hours**

***Outcome:*** ***Interpret block diagrams and describe the North American network systems, digital multiplexing, subscriber interfacing and basic signaling technology.***

1. Describe intra-office call systems.
2. Describe inter-office call systems:
   a) local
   b) 10 digit local dialing
   c) local number portability
3. Describe numbering schemes:
   a) North American
   b) World
   c) IP addressing
4. Describe the North American switched network:
   a) switching office arrangements
   b) Common Channel Signaling
5. Describe the long distance market:
   a) 1 – 800 service
   b) equal access toll and local access
6. Explain a block diagram of a telecommunication system that incorporates:
   a) telephone sets
   b) key equipment
   c) PBX and Centrex
   d) Virtual Corporate Network
   e) cellular/mobile

7. Explain a block diagram of a telecommunication system as it relates to multiplex and carrier systems:
   a) coaxial cable
   b) copper cable
   c) HF and VHF radio
   d) microwave
   e) satellite
   f) fibre optics

**D. Basic Switching System Functions ..... 6 Hours**

***Outcome:*** ***Describe basic switching system functions including interconnecting, functions, control systems and power requirements.***

1. Describe interconnecting.
2. Describe the eight-step operation of a telephone call:
   a) alerting
   b) attending
   c) information transmitting
   d) information translating
   e) busy testing
   f) conversation
   g) supervision
   h) clear & restore
3. Explain block diagrams of a telecommunication system as it relates to:
   a) distribution/concentration/expansion
   b) distributed versus common control
4. Describe DC power requirements of switching systems:
   a) -48 volt battery system

**E. Basic Customer Terminal Equipment ..... 2 Hours**

***Outcome:*** ***Use a block diagram to describe the operation of basic customer terminal equipment and describe the technology trends with customer terminal equipment.***

1. Describe the operation of basic customer terminal equipment using a block diagram:
   a) fax machines
   b) modems
   c) Auto Call Distributor (ACD)
   d) pay phones
   e) Voice over Internet Protocol (VoIP)

**F. Basic Telephony Lab ..... 8 Hours**

***Outcome:*** ***Perform various analyses of telephony operation.***

1. Measure voltage and current on the subscriber loop.
2. Measure frequency response on cables.
3. Perform decibel (dB) loss measurements.
4. Perform noise measurements.

**SECTION SIX: ..... LAN I ..... 24 HOURS**

**A. Network Fundamentals ..... 8 Hours**

***Outcome:*** ***Describe networking including network standards and terminology.***

1. Define and explain the need for networking.
2. Discuss the historical progression of networking starting with ARPANET.
3. Explain the need for standards.
4. Describe the seven layers of the Open Systems Interconnect (OSI) model and its advantages:
   a) data encapsulation process in comparison to the OSI model
   b) OSI model as compared to the (Department of Defense) DOD model
5. Define the following networking terms:
   a) client/server
   b) Network Operating System (NOS)
   c) peer-to-peer
   d) Local Area Network (LAN)
   e) Wide Area Network (WAN)
   f) Metropolitan Area Network (MAN)
   g) Network Interface card (NIC)
   h) switch
   i) router
   j) Dynamic Host Configuration Protocol (DHCP)
   k) Domain Name Services (DNS)
   l) Address Resolution Protocol/Reverse Address Resolution Protocol (ARP/RARP)

**B. Network Devices ..... 8 Hours**

***Outcome:*** ***Describe physical layer, data link layer and network layer devices.***

1. Describe the function of the following layer 1 components:
   a) transmission media
   b) connection components (jacks, plugs, patch panels, cable usage)
   c) transceivers
   d) repeaters
   e) hubs
2. Describe physical LAN topologies:
   a) bus
   b) star
   c) ring
3. Describe the function of the following Layer 2 components:
   a) NIC
   b) Media Access Control (MAC) addressing
   c) bridges
   d) switches
   e) framing
4. Explain the concept of collision domains:
   a) Collision Sense Multiple Access/Collision Detect (CSMA/CD)
   b) Half Duplex versus Full Duplex

5. Explain the concept of MAC broadcast domains.
6. Describe media access control protocols:
   a) Ethernet
   b) Token ring
   c) Fibre Distributed Data Interface (FDDI)
7. Describe the function of routers:
   a) network addressing
   b) network segments
   c) basic path determination
8. Explain physical and logical addresses:
   a) physical (hardware) address (MAC)
   b) logical (host) address (IP)
9. Describe where the devices fit within the enterprise network architecture:
   a) network hierarchy

**C. IPv4 Addressing.....8 Hours**

***Outcome:*** ***Explain the purpose of IPv4 addressing.***

1. Explain the process of converting decimal to binary and binary to decimal as it relates to the IPv4 addressing scheme.
2. Describe the classes and breakdown of IP addressing:
   a) classes
   b) public addressing versus private
3. Explain IP subnetting.
4. Identify the common components of an IP addressing configuration on a host:
   a) client IP
   b) subnet mask
   c) gateway IP
   d) DNS IP

**SECOND PERIOD TECHNICAL TRAINING**
**COMMUNICATION TECHNICIAN TRADE**
**COURSE OUTLINE**

*UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.*

**SECTION ONE:..... ELECTRONICS..... 48 HOURS**

**A. Active Electronic Components ..... 8 Hours**

***Outcome:*** ***Explain the operation and advantages of diodes, transistors and field effect transistors.***

1. Explain PN junction diode functions:
   a) rectifier and small signal diode
   b) zener diode
   c) LED (including seven segment display)
   d) explain the diode curve
2. Explain transistor functions:
   a) describe forward bias
   b) describe reverse bias
   c) identify transistor symbols
   d) explain the beta current relationship
3. Explain FET operation:
   a) amplifier
   b) switch
4. Describe CMOS.

**B. Power Supplies ..... 8 Hours**

***Outcome:*** ***Describe the operation of a power supply.***

1. Describe the function of:
   a) transformers
   b) rectifiers
   c) filters
   d) regulators

**C. Amplifiers ..... 8 Hours**

***Outcome:*** ***Understand amplifier applications.***

1. Describe the purpose of an amplifier:
   a) large and small signal amplifiers
   b) single-ended and differential amplifiers
   c) amplifier black box parameters

**D. Electronics Lab ..... 24 Hours**

***Outcome:*** ***Conduct various lab exercises on power supplies & regulators and amplifiers.***

1. Identify and describe common lab equipment, procedures and safe use.
2. Measure and verify DC output and ripple.
3. Verify correct power supply function.
4. Measure and verify transistor circuit voltages, currents, phase and gain.
5. Verify correct amplifier operation.
6. Construct an IC operational amplifier circuit:
   a) comparator
   b) inverting amplifier
   c) non-inverting amplifier
7. Build and test first-order RC active filters:
   a) low pass filter
   b) high pass filter
   c) band pass filter
8. Connect an IC regulator to a power supply.

**SECTION TWO: ..... WIRING II ..... 64 HOURS**

**A. Analysis of Wiring I Concepts ..... 4 Hours**

***Outcome:*** ***Discuss Wiring I concepts.***

1. Re-examine Wiring I concepts:
   a) the current industry acceptable cabling standards used
   b) the differences of OSP and SCS
   c) grounding and bonding requirements
   d) evaluate procedures and practices

**B. Copper Cable ..... 8 Hours**

***Outcome:*** ***Select correct copper cable systems for higher data rates (>CAT5e) when planning and installing building wiring systems.***

1. Define and explain:
   a) noise
   b) crosstalk
   c) cable twists
   d) impedance
   e) attenuation
2. Define and explain:
   a) coaxial cable characteristics
   b) electrical properties
   c) use in networks

3. Define and explain:
   a) Unshielded Twisted Pair (UTP) characteristics
   b) Shielded Twisted Pair (STP) characteristics
   c) Screened Twisted Pair (ScTP) or Foil Twisted Pair (FTP) characteristics
   d) Legacy IBM cable types
4. Define and explain:
   a) channel and permanent link length required
   b) flammability (FT-4, FT-6 and plenum ratings) and fire-stop techniques
   c) higher classifications (CAT 6, 6 augmented, 10 Giga 6A, and CAT 7)

**C. Fibre Optic Cable ..... 8 Hours**

***Outcome:*** ***Select the correct fiber optic (FO) cabling when planning and installing building wiring systems under the ANSI/TIA/EIA-568-B.3 standard.***

1. Describe the following:
   a) optical fiber cable types (Multimode and single mode)
   b) FO transmission performance (bandwidth) parameters
   c) maximum attenuation and minimum return loss
   d) types of FO equipment (i.e.: transmitters and receivers)
   e) bend radius (static and dynamic)
   f) aerial installation versus direct buried installation techniques
   g) proper indoor installation practises
   h) types of FO patch panels and splice enclosure
   i) types of FO connectors
2. Troubleshoot fibre optics systems and perform acceptance tests (using industry accepted hand-held meters).

**D. Balanced Twisted Pair Cabling Components ..... 6 Hours**

***Outcome:*** ***Select the correct standards and equipment required for high-speed (wide bandwidth) systems under the ANSI/TIA/EIA-568-B.2 standard.***

1. Identify and describe copper cable termination components.
2. Identify and describe the following types of connectors:
   a) data
   b) 25-pair (BIXs, R66 and 110)
   c) coaxial
3. Identify and describe types of panels and blocks:
   a) patch panel
   b) punch-down block (RJ-45)
4. Describe application guidelines.
5. Describe work area outlets.

**E. Cable Administration ..... 4 Hours**

***Outcome:*** ***Understand and apply industry acceptable administration standards for OSP and SCS under the ANSI/TIA/EIA-606-A standard.***

1. Describe the four classes of administration.
2. Describe the color coding of termination fields.
3. Describe the labelling, linkage and report procedures.
4. Describe the color specifications.
5. Describe general cable documentation guidelines.
6. Describe electronic administration software.

**F. Residential Building Concepts..... 10 Hours**

***Outcome:*** ***Understand and apply industry acceptable cabling standards for residential (home) systems under the ANSI/TIA/EIA-570-B standard.***

1. Describe the components of the Residential Telecommunications Cabling Standard.
2. Describe the basic infrastructure of a home network cabling system.
3. Describe the proper procedures for installing a residential cable infrastructure.
4. Recognize and interpret the various residential cabling mediums used.
5. Describe the procedures required to test a completed cable system.

**G. Methodology of Cable Testing and Related Lab ..... 8 Hours**

***Outcome:*** ***Plan and install a cable system that will meet or exceed the required standards for certification.***

1. Describe general cable installation guidelines.
2. Describe inter-building cables (backbone).
3. Explain how to terminate cables.
4. Describe building grounding and bonding (Under ANSI/TIA/EIA-607standard).
5. Explain surge protection.
6. Describe component, link and channel testing (with Labs).
7. Describe field testing methods (with Labs).
8. Explain the different types of copper certification tests (with Labs).
9. Explain FO certification tests.
10. Explain ISO/IEC cable tests.
11. Describe cable management systems.
12. Describe the convergence of LANs and cabling systems.

**H. Advanced Building Wiring and Termination Lab ..... 16 Hours**

***Outcome:*** ***Use correct procedures for installing high-bandwidth (>CAT 5e) building wiring systems.***

1. Demonstrate cable planning and layout to specified standards.
2. Install fibre optic and copper cable.
3. Demonstrate patch panel terminating.

4. Terminate workstation outlets.
5. Perform cable testing and certification of copper cable to specified standards.

**SECTION THREE: .....LOGIC CIRCUITS..... 32 HOURS**

**A. Basic Logic Circuits ..... 16 Hours**

***Outcome:*** ***Describe basic logic gates and their fundamental applications.***

1. Describe primary logic gates:
   a) AND
   b) OR
   c) NOT
2. Describe universal logic gates:
   a) NAND
   b) NOR
   c) XOR
3. Explain simple combinational logic applications.
4. Explain nand gate flip flops:
   a) SR (clocked and unclocked)
   b) "D" flip flops
   c) J-K flip flops
5. Explain the operation and application of the following devices:
   a) 555 timer
   b) buffers
   c) counters
   d) A/D-D/A converters

**B. Logic Circuit Lab ..... 16 Hours**

***Outcome:*** ***Build and test logic circuits.***

1. Identify and describe common lab equipment, procedures and safe use.
2. Build and test simple circuits using basic gates:
   a) RS and D type flip flops using NAND gates
   b) J-K flip flops
3. Demonstrate the operation and application of the following devices:
   a) 555 timer
   b) buffers
   c) counters
   d) A/D-D/A converters

## SECTION FOUR: ..... BASIC TRANSMISSION ..... 24 HOURS

### A. Introduction ..... 4 Hours

***Outcome:*** ***Describe basic transmission concepts of communication networks.***

1. Identify and describe types of waveforms:
   a) sinusoidal
   b) non-sinusoidal
2. Describe the characteristics of pulse waveforms:
   a) pulse amplitude
   b) leading edge
   c) trailing edge
   d) time period
   e) pulse repetition rate
   f) pulses per second
   g) pulse width
   h) pulse duration
   i) duty cycle
   j) rise time
   k) fall time
3. Describe the harmonic content of waveforms:
   a) frequency synthesis
   b) harmonic analysis
   c) Fourier analysis
4. Describe bandwidth requirements of the following applications:
   a) human voice
   b) video
   c) LANs
   d) CATV
   e) wireless
5. Calculate and explain the relationship between:
   a) dB and power ratio
   b) dB and voltage ratio
   c) dBm and dB relative to a reference
6. Define the following terms:
   a) logarithms
   b) decibels dB
   c) decibel Levels dBm, dBW, dBmV, dBrn
7. Describe the use and application of the following meters:
   a) level meters (dB/dBm)
   b) frequency selective level meter
   c) digital dBm meter

8. Describe the following reading types:
   a) bridged
   b) terminated
   c) common errors
9. Describe Test Level Points (TLP), Data Level Points (DLP) and system level measurements.
10. Define the concept of dBm0.
11. Describe the following as related to the message channel:
   a) level
   b) distortion
   c) crosstalk
   d) echo and singing
   e) noise
   f) customer expectations
12. Describe energy distribution of speech and hearing.
13. Discuss the characteristics of the transmission channel for:
   a) voice
   b) data
   c) music and video

**B. Four-Wire Terminal Networks and Hybrid Circuits ..... 4 Hours**

***Outcome:*** ***Explain attenuation, identify selected types of attenuators, and identify & manipulate hybrid circuits.***

1. Describe attenuation and attenuators.
2. Describe Characteristic Impedance.
3. Identify and describe types of hybrids.
4. Discuss hybrid losses:
   a) insertion
   b) hybrid
   c) trans-hybrid
   d) return loss
5. Explain echo and singing.
6. Define standard test tone levels for hybrid circuits.
7. Describe balancing a network and compare with balancing a line.

**C. Transmission Lines Equalization Loading ..... 8 Hours**

***Outcome:*** ***Explain the characteristics of transmission lines including equalization, loading and transmission line noise impairment.***

1. Describe the similarities of transmission line and 4-wire terminal networks.
2. Describe the primary constants of Characteristic Impedance on Characteristic Impedance and attenuation.
3. Explain the variation of Characteristic Impedance with frequency.

4. Describe Characteristic Impedance termination:
   a) impedance mismatch
   b) cause and effect of reflection
   c) how reflection can be reduced
5. Describe secondary propagation constants as they relate to loading:
   a) attenuation/decay
   b) phase relationships (graphical representation)
6. Explain the purpose and effects of loading:
   a) coil spacing and build out capacitors
   b) optimum transmission (LG=RC)
   c) frequency spectrum
   d) propagation
   e) loading schemes
   f) loaded and non-loaded line characteristics
7. Show velocity of propagation characteristics (graphical representation).
8. Describe the following propagation concepts:
   a) loss
   b) velocity and velocity factor
   c) phase shift
9. Describe the function of the following types of equalization:
   a) amplitude
   b) decay
   c) attenuation
   d) phase
10. Describe common applications of equalization.

**D. Basic Transmission Lab ..... 8 Hours**

*Outcome:* ***Perform prescribed lab exercises with decibel measurements, pads & attenuators, transmission lines, cable loading, TDR measurements, hybrid circuits and noise measurements.***

1. Measure pulse characteristics.
2. Perform decibel measurements.
3. Verify Zo and loss characteristics of pads and transmission lines.
4. Verify transfer characteristics of loaded and non-loaded lines.
5. Perform Time Domain Reflectometer (TDR) measurements.
6. Perform decibel measurements for a hybrid circuit.
7. Perform noise measurements on transmission mediums.

**SECTION FIVE: .....FIBRE OPTICS ..... 32 HOURS**

**A. Introduction to Fibre Optics Theory .....24 Hours**

***Outcome:*** ***Explain the operation of fibre optics including light transmission, optical fibre, cables & cable connectors, transmission & reception, system components and testing.***

1. Discuss the history of fibre optics.
2. Describe information transmission.
3. Identify and describe the advantages of fibre optics.
4. Contrast and compare copper and fibre.
5. Describe safety issues associated with:
   a) glass fibre
   b) laser equipment and tools
6. Describe electromagnetic spectra.
7. Describe geometrical optics:
   a) reflection and refraction
   b) Snell's Law
   c) Principle of total reflection
   d) Fresnel reflection
8. Describe optical fibre construction.
9. Describe optical fibre classifications:
   a) multimode step index fibre
   b) multimode graded index fibre
   c) single mode step index fibre
10. Describe optical fibre characteristics:
    a) modal dispersion
    b) material dispersion
    c) dispersion shifted fibres
    d) fibre bandwidth
    e) numerical aperture and the number of modes
    f) attenuation, scattering and transmission windows
11. Describe buffer types.
12. Describe inside cables.
13. Describe outside cables.
14. Describe connector basics and requirements.
15. Identify and describe types of connectors.
16. Describe splices:
    a) fusion splice
    b) mass fusion splice
    c) mechanical splice
17. Describe passive couplers.

18. Describe light sources and transmitters:
    a) LED and laser
    b) light modulation and basic transmitter topology
    c) transmitter power rating
19. Describe detectors and receivers:
    a) PN, PIN and APD detectors
    b) noise in photo detectors
    c) basic receiver concepts
20. Describe loss budget.
21. Describe bandwidth budget.
22. Describe Dense Wave Division Multiplexing (DWDM).
23. Describe optical fibre signal regeneration techniques.
24. Describe fibre networks:
    a) centralized network
    b) distributed network
    c) computer system network
    d) broadband application
25. Discuss current trends in fibre networks:
    a) Fibre to the Curb (FTTC)
    b) Fibre to the Home (FTTH)
    c) Fibre to the Building (FTTB)
    d) Video On demand (VOD)
26. Identify test equipment.
27. Describe standard tests:
    a) OFSTP-14
    b) FOTP-141
    c) FOTP-61
28. Describe optical time domain reflectometry (OTDR).

**B. Fibre Optics Lab ..... 8 Hours**

***Outcome:*** ***Perform connectorization, fibre splicing, loss measurement and OTDR testing.***

1. Install hot melt connectors:
    a) fibre preparation
    b) installing the connector
    c) connector polishing
    d) connector inspection and loss estimation
2. Perform fusion splicing.
3. Perform loss measurement using light source and power meter.
4. Perform OTDR testing:
    a) understanding of OTDR equipment and the dead zone
    b) basic OTDR testing
        i) fibre attenuation
        ii) splice loss
        iii) link loss

**SECTION SIX:..... LAN II ..... 40 HOURS**

**A. Transport Layer Protocols..... 2 Hours**

***Outcome:*** ***Describe various transport layer protocols.***

1. Explain the operation of connection oriented versus connectionless protocols:
   a) identify connection oriented protocols
   b) identify connectionless protocols
2. Explain the concept of port numbers.

**B. Switching and Virtual LANs (VLAN) ..... 6 Hours**

***Outcome:*** ***Describe the functional characteristics of switches and VLANS.***

1. Describe the physical and logical function of a switch:
   a) forwarding table structure
   b) spanning tree protocol (STP)
      i) flood, filter, forwarding operation
      ii) broadcast domain limit
      iii) collision domain limit
2. Describe the functionality of VLANs:
   a) purpose of VLANs
   b) VLAN forwarding structure
   c) impact of VLANS on broadcast domains
3. Troubleshooting a VLAN:
   a) impact of legacy equipment
   b) VLAN to VLAN communications

**C. Inter VLAN Communications..... 8 Hours**

***Outcome:*** ***Describe the process of interVLAN communications.***

1. Describe the placement of ethernet switches in the network:
   a) typical architecture of a switched LAN
   b) components for interVLAN communications
      i) router
      ii) layer three switch (L3)
   c) VLAN identifiers
   d) switch management
      i) local versus remote management
2. Describe the functions of VLAN trunking:
   a) trunking protocol standards
   b) multiple spanning tree implementations

**D. Network Lab ..... 24 Hours**

***Outcome:*** ***Perform prescribed lab exercises including building a basic LAN architecture and testing its functionality.***

1. Perform the following actions on a switch:
   - a) verify no collision domain
   - b) verify MAC address learning capability
   - c) verify STP operation
   - d) verify and troubleshoot host connectivity
2. Configure and implement a VLAN:
   - a) VLAN structure/numbering scheme
   - b) test for host connectivity without interVLAN communications
3. Configure and implement interVLAN communications:
   - a) VLAN trunking
   - b) multiple spanning tree operation
   - c) verify interVLAN connectivity
     - i) router implementation
     - ii) L3 switch implementation
     - iii) test for host connectivity with interVLAN communications
4. Use software to capture and identify packet data:
   - a) identify the functions of a packet analysis application
   - b) identify fields in layer two header formats
     - i) broadcast
     - ii) unicast
   - c) identify fields in layer three and layer four header formats
     - i) ARP
     - ii) IP
     - iii) TCP or UDP
     - iv) ICMP (Internet Communications Messaging Protocol)
     - v) DHCP
     - vi) Internet traffic and related protocols

**THIRD PERIOD TECHNICAL TRAINING**
**COMMUNICATION TECHNICIAN TRADE**
**COURSE OUTLINE**

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**SECTION ONE:.....ACCESS TECHNOLOGY I..... 80 HOURS**

**A. Overview of Data Communications ..... 8 Hours**

***Outcome:*** ***Describe a basic data communications system including terminology and factors that affect the communications path.***

1. Describe the fundamentals of a data communications system:
   - a) transmitter (modulator)
   - b) medium (facility)
   - c) receiver (demodulator)
   - d) requirements of machine-to-machine communications
2. Explain the terminology associated with the data communications system:
   - a) Data Communications Equipment (DCE)
   - b) Data Terminal Equipment (DTE)
     - i) device management (human machine interface)
     - ii) terminal emulation software (Hyperterminal, Tera Term)
   - c) Data Service Unit/Channel Service Unit (DSU/CSU)
3. Explain factors that affect an electrical communications path:
   - a) resistance, capacitance, inductance
   - b) cable make-up (gauge changes)
   - c) impedance mismatch
   - d) power influence
   - e) cross talk
   - f) noise
4. Describe the requirements for digital transmission:
   - a) effects of load coils
   - b) bridge taps
   - c) line length
   - d) DC continuity
   - e) digital loop disturbers (spectral compatibility)
5. Describe asynchronous and synchronous data transmission.
6. Explain data transmission speeds (bit rate and baud rate).
7. Describe methods of error detection and correction.

**B. Characteristics of Digital Signals ..... 8 Hours**

***Outcome:*** ***Describe the characteristics and limitations of digital signals.***

1. Describe time domain characteristics.
2. Describe frequency domain characteristics.
3. Describe and analyze rectangular waves:
   a) spectrum analysis
   b) harmonic nulling factor
   c) wave shaping
4. Describe the frequency bandwidth limitations of the line using the following communications theorems:
   a) Shannon's Theorem
   b) Nyquist Theorem

**C. Line Codes ..... 16 Hours**

***Outcome:*** ***Describe line coding techniques including modulation schemes and multilevel signals.***

1. Describe the reasons for, and the requirements of, line encoding:
   a) analog line limitations
      i) frequency limits of copper cable
      ii) attenuation
      iii) capacitance
      iv) inductance
   b) clock recovery
   c) bandwidth efficiency
   d) duty cycle
   e) power spectrum
   f) reach
2. Define the terms and describe the characteristics of the following encoding signals:
   a) baseband signals
   b) Non Return to Zero (NRZ)
      i) unipolar
   c) Return to Zero (RZ)
   d) Alternate Mark Inversion (AMI)
      i) Bipolar
3. Explain methods of overcoming line code problems:
   a) Bipolar Violations (BPV)
   b) Zero Code Suppression (ZCS)
      i) Jam Bit 7 (JB-7)
   c) Binary n-Zero Code Substitution (BnZS)
      i) B8ZS
      ii) B6ZS
      iii) B3ZS

4. Describe timing methods:
   - a) regenerative timing
     - i) recovered clock
   - b) Building Integrated Timing Source (BITS)

5. Explain the following modulation techniques:
   - a) Amplitude Modulation (AM)
     - i) Amplitude Shift Keying (ASK)
   - b) Frequency Modulation (FM)
     - i) Frequency Shift Keying (FSK)
   - c) Phase Modulation (PM)
     - i) Phase Shift Keying (PSK)

6. Explain how to overcome bandwidth limitations by using multilevel signals:
   - a) Two Binary One Quaternary (2B1Q)
   - b) Quadrature Phase Shift Keying (QPSK)
   - c) Quadrature Amplitude Modulation (QAM)

7. Explain Integrated Services Digital Network (ISDN):
   - a) describe the purpose of ISDN
   - b) describe Basic Rate Interface (BRI) 2B + D
     - i) explain the purpose of the B channels
     - ii) explain the purpose of the D channel
   - c) define line rate
   - d) describe Primary Rate Interface (PRI) 23 B + D
     - i) bandwidth allocation
     - ii) customer premise equipment

8. Describe Digital Subscriber Line (DSL) codes:
   - a) coding schemes
     - i) Inverse Fast Fourier Transform (IFFT)
     - ii) Fast Fourier Transform (FFT)
   - b) Discrete Multi Tone (DMT)
     - i) DMT 1
     - ii) DMT 2
   - c) framing schemes

9. Describe Ethernet codes:
   - a) 10 Megabit
   - b) 100 Megabit
   - c) Gigabit (GigE)
   - d) 10 Gigabit

**D. Carrier Facilities..... 8 Hours**

***Outcome:*** ***Describe the fundamentals of carrier facilities.***

1. Describe a T1 carrier system:
    a) line repeater operation
    b) simplex power feed
    c) terminal equipment
    d) line terminating equipment
    e) repeater line equipment
2. Describe an optical carrier system:
    a) terminology
    b) components
    c) terminal equipment architecture
    d) amplification
    e) regeneration

**E. Network Access Devices ..... 8 Hours**

***Outcome:*** ***Describe the operation of modems, explain communication links & modes of operation and understand interface standards of data communication equipment.***

1. Describe the function and operation of a modem.
2. Describe the basic elements of a modem:
    a) transmitter section
    b) receiver section
    c) control and timing sections
3. Describe common interface standards such as:
    a) RS232 (EIA232)
    b) EIA422/423
    c) EIA449
    d) EIA530
4. Identify and describe types of Data Communications Equipment (DCE):
    a) dial-up modems (internal/external)
    b) dedicated modem
        i) line drivers
        ii) Data Service Unit/Channel Service Unit (DSU/CSU)
        iii) fibre optic transceivers
    c) 2W and 4W
5. Describe the V.xx standards and protocols for modems.
6. Describe the AT command set.
7. Describe error detection and correction techniques.
8. Explain data compression.
9. Explain the following types of transmission modes:
    a) Simplex
    b) Half Duplex (HDX)
    c) Full Duplex (FDX)

10. Identify and describe the advantages and disadvantages of the following types of networks:
    a) switched
    b) dedicated
        i) point-to-point
        ii) multi-drop

**F. Access Technology I Lab ..... 32 Hours**

***Outcome:*** ***Perform prescribed lab exercises on a communication system.***

1. Use terminal software to communicate with channel components.
2. Analyze time and frequency domains.
3. Install and configure various modems.
4. Verify signalling handshake and timing.
5. Measure various circuit impairments.
6. Investigate communication channel performance using multiple configurations.
7. Perform bit error testing.
8. Perform AT commands on a dial-up modem.
9. Set up a point-to-point and a multipoint router interface and verify its operation.

**SECTION TWO: ..... MULTIPLEXING ..... 24 HOURS**

**A. Introduction to Multiplexing Fundamentals ..... 8 Hours**

***Outcome:*** ***Describe multiplexing and the digital hierarchy.***

1. Define multiplexing and how it fits into telecommunications systems.
2. Describe types of multiplexing including:
    a) Frequency Division Multiplexing (FDM)
    b) Time Division Multiplexing (TDM)
    c) Statistical Time Division Multiplexing (STDM)
    d) Wave Division Multiplexing (WDM)
3. Describe the creation of a digital bit stream (Pulse Code Modulation (PCM)):
    a) sampling
        i) Nyquist Sampling Rate
        ii) Pulse Amplitude Modulation (PAM)
        iii) Aliasing noise
    b) quantizing
    c) encoding

4. Describe the multiplexing of bit streams:
   a) creation of a level one Digital Signal (DS-0)
      i) frames
      ii) synchronization methods
      iii) signaling
   b) North American digital hierarchy
      i) DS-1 signal format
      ii) DS-2 signal format
      iii) DS-3 signal format
   c) describe European digital hierarchy
      i) E-1 signal format
      ii) E-2 signal format
      iii) E-3 signal format
      iv) E-4 signal format
   d) describe Synchronous Digital Hierarchy (SDH)
   e) describe Plesiosynchronous Digital Hierarchy (PDH)
5. Describe the optical multiplexing hierarchy:
   a) Synchronous Transport Signal (STS)
   b) Optical Carrier level One (OC-1)
   c) Optical Carrier level Three (OC-3)
   d) Optical Carrier level Twelve (OC-12)
   e) Optical Carrier level Forty-Eight (OC-48)
   f) Optical Carrier level One Ninety Two (OC-192)
   g) Optical Carrier level Seven Sixty-Eight (OC-768)
6. Describe wavelength division multiplexing terminology:
   a) Lambda (λ)
   b) Common wavelengths (850 nm, 1300 nm, 1550 nm)
   c) Passive Optical Network (PON)
   d) Coarse Wavelength Division Multiplexing (CWDM)
   e) Dense Wavelength Division Multiplexing (DWDM)

**B. Multiplexing Systems ..... 8 Hours**

***Outcome:*** ***Describe network multiplexer systems.***

1. Describe multiplexing devices:
   a) M1-3 multiplexer
   b) Smart Channel Banks
      i) Fractional T1
      ii) DS0 (single data channel)
   c) Sub Rating
   d) Digital Subscriber Line Access Multiplexers (DSLAM)
   e) Statistical Multiplexing
      i) Asynchronous Transfer Mode (ATM)
   f) Coarse Wavelength Division Multiplexing (CWDM)
   g) Dense Wavelength Division Multiplexing (DWDM)
   h) Passive Optical Network (PON)

2. Describe the applications of network multiplexing devices:
   a) access
      i) channel banks
      ii) Coarse Wavelength Division Multiplexers (CWDM)
      iii) passive optical splitters
   b) distribution
      i) Digital Access Cross-connect System (DACS)
      ii) Mini-DACS
   c) core
      i) Add-Drop Multiplexer (ADM)
      ii) Dense Wavelength Division Multiplexer (DWDM)
      iii) Optical Cross-Connect (OXC)

**C. Digital Multiplexing Lab ..... 8 Hours**

***Outcome:*** ***Perform selected digital multiplexing lab exercises.***

1. Configure various types of end-to-end circuits.
2. Configure a DSL line.

**SECTION THREE: .....NOISE MITIGATION..... 32 HOURS**

**A. Introduction ..... 4 Hours**

***Outcome:*** ***Define noise, noise types, noise measurement and describe the various sources of noise and their effects.***

1. Define and explain noise in relation to transmission:
   a) mitigation
   b) importance to transmission
2. Define the basic noise types:
   a) white, thermal, random
   b) cross talk
      i) near end cross talk (NEXT)
      ii) far end cross talk (FEXT)
   c) impulse
   d) intermodulation
   e) quantization
   f) background
3. Describe noise measurement:
   a) dBm & levels
   b) dBrn
   c) dBrnC and C filter
   d) milliwatt supply
   e) correct termination requirements

4. Describe the various sources of noise:
   a) AC power influence
   b) central office power supply
   c) electromagnetic inductance
   d) radio frequency interference
   e) effects of temperature on noise
   f) electrical devices
   g) singing/echo
   h) lightning
   i) electric motors
5. Identify and describe transient noise sources on communication facilities:
   a) sheath currents
   b) line surges
   c) static

**B. Influencing Factors ..... 6 Hours**

***Outcome:*** ***Describe influencing factors including power system design and telephone & power line misbalance causes.***

1. Explain basic power system design and concepts:
   a) power distribution
   b) power neutrals
   c) single wire ground return
   d) AC grounding methods
   e) return currents
2. Identify and explain power system characteristics:
   a) balanced/unbalanced loads
      i) feedback current
   b) sinewave & harmonics
   c) power abnormalities
   d) transient power
   e) transverse & longitudinal currents
3. Explain the theory of twisted pair noise coupling:
   a) inductive
   b) capacitive

**C. Noise Mitigation Techniques and Devices ..... 6 Hours**

***Outcome:*** ***Identify and explain noise mitigation techniques and devices.***

1. Explain the methods and theory of the following techniques:
   a) equipment shielding and shielding currents
   b) surge protection
   c) grounding, bonding and single point grounding system (SPGS)
   d) Multi ground Neutral (MGN)

2. Identify and describe the devices designed to minimize mitigation:
   a) isolation transformers
   b) noise filters
   c) chokes
   d) drain coils
   e) induction neutralizing transformers
   f) surge protectors

**D. Noise Measurements and Equipment Lab ..... 16 Hours**

***Outcome:*** ***Use noise measurement equipment and perform noise measurement tests.***

1. Perform noise measurements with associated equipment:
   a) measure loop parameters using milliwatt supply
   b) measure battery and rectifier noise
   c) show noise measurement errors
   d) perform harmonic distortion measurements
   e) find faults using artificial line
   f) perform balance and noise tests

**SECTION FOUR: ..... DC POWER PLANTS ..... 32 HOURS**

**A. Safety Requirements ..... 2 Hours**

***Outcome:*** ***Apply the relevant safety regulations and practices when working with DC power plants.***

1. List and describe safety regulators and the scope of regulations:
   a) WHMIS
   b) Canadian Electrical Code
   c) Electrical Protection Act
2. Describe the legal aspects of safety.
3. List and describe battery and rectifier safety considerations.
4. List and describe required safety equipment.
5. Describe general safety rules.

**B. Introduction to DC Power Plants ..... 8 Hours**

***Outcome:*** ***Describe the basic components and purpose of DC power plants and explain AC theory as applied for conversion from AC to DC.***

1. Identify and describe the basic components of a DC power plant.
2. Describe the purpose of DC power plants.
3. Explain AC theory for conversion from AC to DC.
4. Explain uninterruptible power supplies (UPS).
5. Describe how control panel functions are accomplished.

**C. Batteries ..... 6 Hours**

***Outcome:*** ***Describe basic battery components and use batteries safely in a variety of operating conditions.***

1. Describe basic battery components.
2. Explain the theory of battery charging and discharging.
3. Describe the effects of temperature on batteries.
4. Describe battery safety rules.
5. Describe methods for inspecting and cleaning batteries.

**D. Rectifier Operation ..... 4 Hours**

***Outcome:*** ***Describe basic rectifier components and the functions of secondary power plant inverters and converters.***

1. Identify and describe basic rectifier components.
2. Describe the operation of ferroresonant, SCR, and switch mode rectifiers including controls, alarms, and connections.
3. Describe rectifier safety rules.
4. Describe the application of meter shunts in rectifier circuits.
5. Describe the function of an inverter.
6. Draw a basic schematic block diagram of a typical inverter and label each component.
7. Describe the function of a converter.
8. Describe a basic schematic block diagram of a typical converter and label each component.
9. Describe the purpose of a converter common panel.

**E. Distribution and Alarms ..... 4 Hours**

***Outcome:*** ***Describe the distribution of DC power plants and explain the operation of combined, rectifier and fuse alarms.***

1. Describe the distribution of a DC power plant.
2. Describe how alarms from various pieces of equipment can be combined together.
3. Explain how rectifier alarms are identified as minor and major.
4. Describe how fuse alarms are extended.

**F. Power Plant Lab ..... 8 Hours**

***Outcome:*** ***Perform prescribed measurements and adjustments on power plant equipment.***

1. Perform the following measurements:
   a) battery float voltage
   b) battery equalize voltage
   c) AC distribution voltage
   d) shunt voltage measurement
   e) strap test voltage drop
   f) specific gravity
   g) individual cell voltage
   h) temperature
   i) voltage drop from rectifier to battery string

2. Perform the following adjustments:
    a) rectifier float voltage
    b) rectifier equalize voltage
    c) rectifier current limit adjustment
    d) rectifier alarm adjustments

**SECTION FIVE: .....LAN III..... 72 HOURS**

**A. Router Basics.....8 Hours**

***Outcome:*** ***Describe physical and logical router characteristics.***

1. Describe common router components such as:
    a) Read Only Memory (ROM)
    b) Flash memory
    c) Non-volatile Random Access Memory (NVRAM)
    d) Random Access Memory (RAM)
    e) Router interfaces
        i) Ethernet/Fast Ethernet
        ii) Serial Interfaces
        iii) Specialized Interfaces including VOIP, SNA, etc.
2. Discuss router configuration:
    a) access methods used to configure a router
        i) Console port
        ii) Telnet
        iii) Auxiliary port
        iv) Configuration management utility
    b) user, privileged and configuration modes
        i) help function options of a router
        ii) configuration editing options
    c) router configuration modes
        i) global parameters
        ii) interface parameters
        iii) routing parameters
        iv) administrative access parameters

**B. Routing Foundations I .....10 Hours**

***Outcome:*** ***Describe routing mechanisms.***

1. Describe the functional characteristics of a typical router:
    a) routing table
    b) packet forwarding
    c) broadcast domain
    d) boot sequence
2. Identify current interior routing protocols:
    a) distance vector
    b) link state
    c) routing metrics

3. Describe multiple routing protocol implementations:
    a) combination effects of two or more routing protocols
    b) single area versus multiple area configurations
    c) effects of routing protocol redistribution
4. Describe the effects of routing pathway changes:
    a) static versus dynamic routing
    b) default routing
    c) routing updates
    d) routing loops

**C. Route Summarization and Supernetting ..... 8 Hours**

***Outcome:*** ***Discuss the optimization of routing tables.***

1. Discuss Classless Interdomain Routing (CIDR):
    a) route summarization
    b) calculating IPv4 summarization zones
    c) supernetting
        i) achieving route table efficiency
    d) discontiguous networks
        i) no auto summarization
    e) Variable Length Subnet Masking (VLSM)

**D. Routing Protocols ..... 14 Hours**

***Outcome:*** ***Describe routing protocol methodologies.***

1. Discuss distance vector protocols:
    a) Route Information Protocol version 2(RIPv2)
    b) Enhanced Interior Gateway Routing Protocol (EIGRP)
2. Discuss link state protocols:
    a) Open Shortest Path First (OSPF)
        i) single area
        ii) multi-area
    b) Interior System to Interior System Protocol (IS-IS)
        i) routing levels

**E. Quality of Service (QoS) I ..... 8 Hours**

***Outcome:*** ***Describe basic QoS functionality.***

1. Discuss the need for QoS:
    a) effects of network congestion
    b) reasons for traffic priorization
    c) explain the process of end-to-end QoS
        i) customer network
        ii) provider network
        iii) Customer Edge to Provider Edge (CE/PE)

2. Describe common queuing schemes such as:
   a) First In First Out (FIFO)
   b) Weighted Fair Queuing (WFQ)
   c) Class Based Queuing (CBQ)
   d) Low Latency Queuing (LLQ)
3. Explain the use of common congestion management techniques such as:
   a) Tail drop
   b) Weighted Random Early Detection (WRED)
   c) Class Based Weighted Fair Queuing (CBWFQ)

**F. LAN III Network Lab.....24 Hours**

***Outcome:*** ***Perform prescribed lab exercises including configuring basic routing protocols and basic QoS functionality.***

1. Configure RIPv2 routing.
2. Configure EIGRP routing.
3. Configure OSPF routing:
   a) single-area
   b) multi-area
4. Configure IS-IS routing.
5. Implement basic multi protocol routing:
   a) verify route redistribution
6. Configure and verify basic QoS functionality.

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**SECTION ONE:.....VOICE NETWORKS..... 40 HOURS**

**A. Concepts and Structure of Voice Networks ..... 16 Hours**

***Outcome:*** ***Discuss the overall concepts, components and their associated protocols of traditional voice networks.***

1. Define key terms associated with voice networks:
   - a) Public Switched Telephone Network (PSTN)
   - b) digital switching equipment
     - i) DMS (NORTEL)
     - ii) GTD5 (AG COMM Systems)
     - iii) #5 ESS (Lucent)
   - c) classes of switches
   - d) trunks and lines
   - e) circuit switching
   - f) hosts/remotes
2. Describe the architecture of a typical switch:
   - a) Central Processing Unit (CPU)
   - b) operating system software
   - c) switch fabric
   - d) peripheral processor
     - i) Line cards
     - ii) Trunk cards (switch ports)
     - iii) DS-0 Time Slot Assignment (TSA)
3. Compare circuit switching with packet switching:
   - a) bandwidth efficiency
   - b) Quality of Service (QoS)
4. Identify voice network component placement using a block diagram:
   - a) switching plan
   - b) customer connectivity
     - i) PBX
     - ii) Key Systems
     - iii) CENTREX option
     - iv) Individual line service
   - c) cellular connectivity

5. Discuss the interrelationship of voice network components:
   a) numbering plans
      i) World numbering plan
      ii) North American numbering plan
   b) call originating and terminating relationship
      i) Line Equipment Number (LEN)
      ii) Telephone Number (TN)
   c) Call Management:
      i) intra-office
      ii) inter-office
      iii) toll
6. Identify the signalling protocols in use on the network.
7. Discuss switch maintenance practices:
   a) concept of ongoing analysis
   b) scheduled versus on demand diagnostics
   c) software maintenance
   d) centralized maintenance

**B. Key Systems, PBX and Centrex Service ..... 8 Hours**

***Outcome:*** ***Discuss digital key systems, PBX and Centrex service.***

1. Describe the organization, operation and features of a digital key system.
2. Describe the organization, operation and features of a PBX system.
3. Describe the organization, operation and features of the CENTREX service.
4. Discuss current/emerging technologies:
   a) IP-PBX
   b) VoIP trunking
   c) communication servers

**C. Voice Network Protocols ..... 8 Hours**

***Outcome:*** ***Describe the protocols used in the public switched telephone network.***

1. Describe the evolution to a common channel signalling system:
   a) per trunk signaling
   b) limitations of per trunk signaling
2. Describe the concept of Common Channel Signalling (CCS7):
   a) architecture and operation
   b) per trunk signaling versus common channel signaling
   c) CCS7 applications (CMS)
      i) Local Number Portability (LNP)
      ii) Advanced Intelligent Network (AIN)
      iii) 1-800 numbers

**D. Voice Networks Lab ..... 8 Hours**

***Outcome:*** ***Perform selected switching systems lab exercises.***

1. Perform exercises on PBX systems and keysets.

**SECTION TWO: ..... LAN IV ..... 48 HOURS**

**A. Routing Foundations II ..... 8 Hours**

***Outcome:*** ***Discuss higher level protocols and IP conservation.***

1. Discuss basic connectivity terminology:
    a) Firewall
    b) Proxy Server
    c) Demilitarized zone (DMZ)
    d) Connectivity authentication
        i) Point to Point Protocol over Etherrnet (PPPoE)
        ii) MAC address registration and cloning
        iii) Remote Access Dial In User Service (RADIUS)
        iv) Virtual Private Network (VPN)
2. Describe network tiering connectivity:
    a) connectivity options
        i) single homed
        ii) multi homed
    b) connectivity issues
    c) address exhaustion
        i) IPv6
        ii) Network Address Translation (NAT)/Port Address Translation (PAT)
3. Describe Border Gateway Protocol (BGP):
    a) Autonomous System numbers (AS)
        i) public AS
        ii) private AS
    b) route distribution process
        i) connectivity requirements
        ii) internal route synchronization
        iii) route dampening
        iv) route aggregation
4. Describe IPv6:
    a) addressing scheme
    b) implementation
        i) methods
        ii) hardware requirements
        iii) software requirements
        iv) routing issues
        v) configuration issues

5. Explain Network Address Translation (NAT)/Port Address Translation (PAT):
    a) NAT versus PAT
    b) static translations versus dynamic translations
    c) scenarios for mandatory translations
    d) configuration parameters

**B. Multicasting ..... 4 Hours**

***Outcome:*** ***Describe multicasting and its uses.***

1. Describe the basics of multicasting:
    a) addressing structure
        i) layer 3 addressing
        ii) layer 2 addressing
    b) propagation of multicast traffic
2. Describe the uses of multicasting:
    a) route propagation
    b) bandwidth efficiency
3. Explain multicast traffic control:
    a) sparse/dense mode
    b) source destination pairs
    c) filtering

**C. Basic Router Security ..... 6 Hours**

***Outcome:*** ***Describe basic router security features.***

1. Describe Access Control Lists (ACL):
    a) standard
    b) extended
    c) configuring ACLs
    d) placement of ACLs
2. Explain filtering needs:
    a) types of filtering
        i) route filtering
        ii) traffic filtering
    b) queuing requirements
    c) router configuration planning priorities

**D. QoS II ..... 6 Hours**

***Outcome:*** ***Describe network requirements for QoS.***

1. Describe techniques for managing congestion at the access, distribution and core layers:
   - a) access congestion issues
     - i) traffic marking
     - ii) trust
     - iii) queuing
   - b) distribution
     - i) marking enforcement
   - c) core congestion avoidance
     - i) traffic shaping
     - ii) traffic policing
2. Describe QoS/bandwidth tradeoffs:
   - a) identifying and resolving Internal choke points
   - b) identifying external choke points
     - i) connection oriented versus connectionless traffic
     - ii) link speed
   - c) resolving external choke points
     - i) Link Fragmentation and Interleaving (LFI)
     - ii) compression
     - iii) increase bandwidth
     - iv) traffic discard
     - v) Explicit Congestion Notification (ECN)
     - vi) congestion avoidance versus congestion management
     - vii) half duplex, asymmetrical and shared links

**E. Wireless LANs ..... 8 Hours**

***Outcome:*** ***Describe wireless LAN terminology, standards, devices and site preparation requirements.***

1. Explain wireless LAN terminology:
   - a) Service Set Identifier (SSID)
   - b) ad hoc versus infrastructure
   - c) beacon interval
   - d) basic security settings
     - i) Wired Equivalency Privacy (WEP)
     - ii) security key methods
     - iii) open access issues
   - e) configuration tools
     - i) broadcasting networks
     - ii) signal strength
     - iii) autoconnect issues
   - f) hot spot types
2. Describe wireless standards:
   - a) IEEE 802.11x
   - b) IEEE 802.16x
   - c) Bluetooth

3. Describe consumer wireless hardware:
    a) Wireless Access Point (WAP)
    b) wireless bridges
    c) boosters
    d) antenna types
        i) omnidirectional
        ii) directional/unidirectional
        iii) Multiple Input/Multiple Output (MIMO)
        iv) connector types
    e) other devices
        i) Personal Digital Assistant (PDA)
        ii) wireless peripherals
        iii) VoIP phones
4. Describe commercial wireless hardware:
    a) antenna options/types
    b) carrier class versus consumer class
5. Describe site preparation requirements:
    a) proximity to electro-magnetic influences
    b) signal barriers/deadspots
        i) ductwork
        ii) rf influences
        iii) channel separation
        iv) attenuating obstacles

**F. LAN IV Lab.....16 Hours**

***Outcome:*** ***Perform prescribed LAN Lab exercises.***

1. Configure basic BGP.
2. Configure NAT and PAT.
3. Create some ACLs for route and traffic filtering.
4. Implement traffic shaping and policing utilizing link fragmentation and interleaving over a frame relay.
5. Configure a wireless access point in infrastructure mode and verify client association using shared key authentication.

**SECTION THREE: ..... VOIP ..... 32 HOURS**

**A. Protocols ..... 6 Hours**

***Outcome:*** ***Describe selected VoIP protocols keyed to the OSI model.***

1. Describe the following protocols with reference to the OSI model:
   a) Real-time Transport Protocol/Real-time Transport Control Protocol (RTP/RTCP)
   b) H.323 Protocol Suite
      i) hardware elements
      ii) basic protocols
   c) Session Initiation Protocol (SIP)
   d) Voice Codecs
      i) G.711 (PCM)
      ii) G.722
      iii) G.722.1
      iv) G.728
      v) G.729
      vi) Internet Low Bit-rate Codec (ILBC)

**B. Enterprise VoIP Versus Carrier VoIP ..... 6 Hours**

***Outcome:*** ***Compare enterprise and carrier VoIP topologies and identify how they integrate with the public telephone network.***

1. Describe an enterprise VoIP topology:
   a) security and design issues
   b) soft phone clients versus physical VoIP phones
2. Describe a carrier VoIP topology:
   a) consumer premise solution
3. Describe a hybrid approach to VoIP:
   a) IP Centrex
4. Describe interfacing VoIP with the public telephone network.

**C. Alternative VoIP Methods ..... 4 Hours**

***Outcome:*** ***Compare the approaches to VoIP taken by selected providers and discuss emerging trends with VoIP.***

1. Describe and compare the following Internet VoIP providers including:
   a) Skype
   b) Vonage
2. Describe emerging trends with VoIP:
   a) Wireless
   b) Videoconferencing

**D. VOIP Lab ..... 16 Hours**

***Outcome:*** ***Perform prescribed VoIP lab exercises.***

1. Demonstrate the sending and receiving of VoIP calls.
2. Demonstrate the capturing of VoIP call traffic using a packet analyser (Wireshark).
3. Use a progressive design approach and a common lab topology to:
   a) design and configure the basic lab VoIP LAN
   b) configure the above lab to interface with the public telephone network
   c) configure the above lab to add gateway protocols to enable site-to-site internetworking
   d) configure the above lab for a multi-branch enterprise solution
4. Demonstrate voice quality issues.
5. Implement voice quality solutions:
   a) configure QoS for the above lab
   b) modify codec parameters

**SECTION FOUR: ..... VIDEO ..... 32 HOURS**

**A. Video Transmission and Consumer Products ..... 24 Hours**

***Outcome:*** ***Describe video transmission fundamentals including TV transmission, National Television System Committee (NTSC), baseband video, broadband video, Broadband ISDN, digital video, video compression, Advanced Television System Committee (ATSC) (also known as HDTV), transport systems and transmission standards and consumer video products.***

1. Describe the fundamentals of TV transmission:
   a) historical development of television
2. Describe the following systems:
   a) National Television System Committee (NTSC)
      i) describe synchronization
      ii) describe blanking
      iii) colour
      iv) luminance
   b) Phase Alternate Line (PAL)
   c) Sequential Color With Memory (SECAM)
   d) Advanced Television System Committee (ATSC)
      i) Digital Television (DTV)
      ii) High Definition Television (HDTV)
   e) Serial Digital Interface (SDI)
      i) Component Analog Video (CAV)
      ii) Analog to Digital Conversion (A to D)
3. Describe interlacing and progressive scanning.
4. Describe equalization.
5. Describe resolution issues.
6. Describe broadband video:
   a) Cable Television (CATV) distribution
7. Describe B-ISDN.

8. Describe video compression:
    a) Motion Picture Expert Group (MPEG) II
    b) H.261
    c) H.263/H.263++
    d) MPEG IV
    e) H.264
9. Describe standard and high definition TV aspect ratios.
10. Describe video signal formats and transport systems:
    a) Serial Digital Interface (SDI)
    b) Asynchronous Serial Interface (ASI)
11. Describe consumer video products including:
    a) Set top box (STB)
        i) Personal Video Recorder (PVR)
    b) High Definition Multimedia Interface (HDMI)
    c) Digital Video Interface (DVI)
    d) Component Video Cable
    e) Serial Video (S-Video)
    f) Display types
        i) Cathode Ray Tube (CRT)
        ii) Liquid Crystal Display (LCD)
        iii) Plasma
        iv) Digital Light Processing (DLP)
12. Describe streaming video:
    a) Video On Demand (VOD)
    b) Internet Protocol Television (IPTV)
    c) Cellphone/Laptop TV

**B. Video Lab.....8 Hours**

***Outcome:*** ***Perform lab exercises including test and measurement procedures on common signal faults, video signal generation methods, wave form recognition and manipulation techniques, video connectivity, and selected consumer video installation configurations.***

1. Perform selected test and measurement procedures on faulty signals.
2. Generate video signals including:
    a) MPEG
    b) NTSC
    c) HDTV
3. Manipulate wave forms.
4. Set up various video configurations.
5. Set up various consumer video installation configurations.

**SECTION FIVE: ..... ACCESS TECHNOLOGIES II..... 32 HOURS**

**A. Data Networks..... 8 Hours**

***Outcome:*** ***Use a block diagram to describe selected data networks.***

1. Describe the operation of the following data networks using a block diagram:
   - a) Frame Relay (FR)
   - b) Asynchronous Transfer Mode (ATM)
   - c) Integrated Services Digital Network (ISDN)
   - d) Digital Network Access (DNA)
     - i) Channel Banks
     - ii) Digital Access Crossconnect System (DACS)
   - e) Multi Protocol Label Switching (MPLS)

**B. Protocols and Standards of Data Networks ..... 8 Hours**

***Outcome:*** ***Discuss selected protocols and standards in use on data networks.***

1. Describe various standards organizations.
2. Describe common protocols and standards:
   - a) connector standards
     - i) Recommended Standards (RS)
     - ii) Recommended Jack Standard (RJ)
     - iii) Fibre Connectors
   - b) electrical protocols
     - i) RS232
     - ii) RS449
   - c) framing methods
     - i) bit oriented
     - ii) character oriented
   - d) link protocols and connections
     - i) Data Link Connection Identifier (DLCI)
     - ii) Virtual Circuit Identifier (VCI)
     - iii) Virtual Path Identifier (VPI)
     - iv) Permanent Virtual Circuit (PVC)
     - v) Link Management Interface (LMI)
     - vi) Link Access Procedure B (LAPB)
     - vii) Link Access Procedure D (LAPD)
     - viii) Synchronous Data Link Control (SDLC)
     - ix) High-level Data Link Control (HDLC)
     - x) Virtual Private Network (VPN) (as related to MPLS)

**C. Emerging Technologies..... 8 Hours**

***Outcome:*** ***Describe emerging communication technologies based on copper, coaxial, fibre and RF.***

1. Discuss copper-based access devices:
   - a) Asymmetrical Digital Subscriber Line 2+ (ADSL2+)
   - b) Very high data rate Digital Subscriber Line (VDSL); (VDSL2)

2. Discuss coaxial-based access devices:
   a) cable modem
      i) Data Over Cable Service Interface Specification (DOCSIS) 1.0/2.0/3.0
3. Discuss fibre-based access devices:
   a) Fibre Optic Inter Repeater Link (FOIRL)
   b) Giga Bit Interface Connector (GBIC)
   c) Gigabit Passive Optical Network (GPON)
4. Discuss RF-based devices:
   a) Wireless Fidelity (Wi-Fi)
   b) Worldwide Interoperability for Microwave Access (WIMAX)
   c) Evolution-Data Optimized (EVDO)
   d) Satellite (internet access)

**D. Access Technologies II Lab ..... 8 Hours**

***Outcome:*** ***Perform prescribed lab exercises on a communication system.***

1. Use routers to create a frame relay network.
2. Perform fault testing on selected frame relay failures.
3. Set up and test an ADSL circuit.
4. Set up a FOIRL link and perform data traffic testing.
5. Set up a GBIC link and perform data traffic testing.

**SECTION SIX:..... WIRELESS SYSTEMS ..... 56 HOURS**

**A. Wireless Transmission ..... 14 Hours**

***Outcome:*** ***Describe Radio Frequency (RF) fundamentals, transmission lines, radio wave propagation and antennas.***

1. Discuss the history of wireless communication.
2. Describe the radio frequency spectrum and convert between frequency and wavelength.
3. Describe the propagation of radio waves in free space:
   a) calculate power density and electric and magnetic field intensity for waves propagating in free space
   b) calculate free space attenuation and path loss
   c) perform calculations to determine the maximum communication range for line of site propagation
   d) describe ground, space and sky wave propagation
4. Explain path loss and fading in a mobile environment and how such an environment differs from free space.

5. Explain the operational principles of antennas:
   a) radiation
   b) isotropic
   c) dipole
   d) gain
   e) beam width
   f) band width
   g) polarization
   h) impedance
6. Describe the gain, bandwidth and application of each of the following antennas:
   a) half wave dipole
   b) folded dipole
   c) ground plane
   d) Yagi
   e) collinear
   f) horn
   g) parabolic
7. Explain the use of diversity and downtilt in base station antennas.
8. Describe transmission lines and connectors used in wireless applications:
   a) propagation constant
   b) power handling
   c) coaxial
   d) waveguide
   e) connectors
9. Describe standing waves:
   a) impedance mismatches
   b) Voltage Standing Wave Ratios (VSWR)
   c) reflection coefficient
   d) return loss

**B. Conventional FM Radio Communication Fundamentals ..... 4 Hours**

***Outcome:*** ***Describe FM radio system concepts and components.***

1. Explain a block diagram of a basic FM transceiver:
   a) RF amp
   b) mixer/modulator
   c) oscillator
   d) limiter
   e) discriminator/detector
   f) filters
   g) Input/Output Devices (I/O)
   h) squelch circuits
2. Identify and describe types of mobile radio systems:
   a) simplex
   b) half duplex
   c) full duplex
   d) repeatered

3. Describe VHF/UHF devices and components:
   a) duplexers
   b) combiner
   c) multi couplers
   d) impedance matching
   e) isolators
   f) circulators
   g) matched loads
4. Describe methods of using tie lines for remote control of base station transmitters and extending coverage.
5. Describe the trunking concept.

**C. Analog and Digital Cellular Radio Telephone Service ..... 6 Hours**

***Outcome:*** ***Explain the operation of cellular radio telephone systems.***

1. Describe the evolution of the analog mobile telephone system:
   a) General Mobile Telephone Service (GMTS)
   b) Improved Mobile Telephone Service (IMTS)
   c) Advanced Mobile Phone Service (AMPS)
2. Describe the cellular concept:
   a) clustering
   b) frequency re-use
   c) cell splitting
3. Explain the operation of the North American analog cellular telephone systems.
4. Describe digital techniques utilized for conserving spectrum:
   a) Time Division Multiple Access (TDMA)
   b) Code Division Multiple Access (CDMA)
   c) Global System for Mobile communications (GSM)
5. Explain the operation of the North American digital cellular telephone systems.

**D. Satellite Based Systems ..... 3 Hours**

***Outcome:*** ***Describe satellite based systems including block diagrams and system applications.***

1. Describe the basic block diagram for a satellite system.
2. Describe satellite earth orbits:
   a) Low Earth Orbit (LEO)
   b) Medium Earth Orbit (MEO)
   c) Geostationary Earth Orbit (GEO)
3. Explain system applications:
   a) C band
   b) Ku band
   c) Direct To Home (DTH)
   d) Internet satellite service
   e) Low Earth Orbit cellular systems

**E. Wireless Applications ..... 4 Hours**

***Outcome:*** ***Describe applications that use a wireless medium.***

1. Describe applications of wireless devices including:
    a) paging systems
    b) wireless LAN devices
    c) hot spots
    d) computer peripherals
    e) remote control devices
        i) RF
        ii) Infrared
    f) Bluetooth devices
    g) Global Positioning System (GPS)
    h) Supervisory Control and Data Acquisition (SCADA)

**F. Trends in Wireless Technology ..... 3 Hours**

***Outcome:*** ***Describe emerging trends in wireless technology.***

1. Explain the convergence of voice, video and data over wireless networks including:
    a) Short Message Service (SMS)
    b) Smart phones (I-phone; Blackberry, Moto-Q; etc.)
2. Discuss methods of increasing bandwidth to enable future wireless services.
3. Discuss the convergence of entertainment into wireless devices including:
    a) ringtones
    b) MP3 files
    c) downloadable games
    d) Television
    e) Internet

**G. Towers ..... 2 Hours**

***Outcome:*** ***Describe towers including types, grounding arrangements, lighting & appearance and safety precautions.***

1. Describe self-supporting and guyed towers.
2. Describe tower anchors.
3. Describe tower grounding.
4. Describe tower lighting and painting.
5. Describe tower safety precautions.

**H. Broadband Radio Communication Fundamentals ..... 4 Hours**

***Outcome:*** ***Describe broadband radio communications through block diagrams and applications.***

1. Discuss the components of a broadband radio system using a block diagram.
2. Identify and describe applications of broadband communication systems.

## I. Wireless Systems Lab ..... 16 Hours

***Outcome:*** ***Perform selected lab exercises involving mobile radio, cellular radiotelephone, microwave, satellite, path profiling and antenna radiation pattern equipment.***

1. Measure the following transmitter characteristics:
   a) transmit power
   b) transmit frequency
   c) transmit deviation
2. Measure the following receiver characteristics:
   a) 20 dB quieting sensitivity
   b) 12 dB SINAD sensitivity
   c) modulation acceptance bandwidth
3. Carry out antenna performance measurements:
   a) Voltage Standing Wave Ratio (VSWR)
   b) Return Loss
4. Position Direct to Home (DTH) antennas.
5. Measure gain, half power beamwidth, and front to back ratio characteristics of a gain antenna.
6. Perform an RF site survey of an existing WiLAN system.
7. Change WiLAN setting and re-do site survey.

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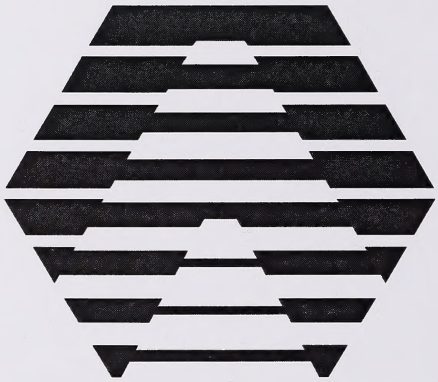

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